Research Paper Review

Recent Advances in the Rehabilitation of ACL Injuries

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ABSTRACT

Rehabilitation following anterior cruciate ligament surgery continues to change, with the current emphasis being on immediate weight bearing and range of motion, and progressive muscular strengthening, proprioception, dynamic stability, and neuromuscular control drills. The rehabilitation program should be based on scientific and clinical research and focus on specific drills and exercises designed to return the patient to the desired functional goals. The goal is to return the patient's knee to homeostasis and the patient to his or her sport or activity as safely as possible. Unique rehabilitation techniques and special considerations for the female athlete will also be discussed. The purpose of this article is to provide the reader with a thorough scientific basis for anterior cruciate ligament rehabilitation based on graft selection, patient population, and concomitant injuries.

ANALYSIS

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Background Information

A whopping 200 000 anterior cruciate ligament (ACL) injuries occur in the United States yearly, leading to approximately 100 000 reconstruction surgeries and extensive and exhaustive courses of rehabilitation. Because of the incredible number of these injuries that occur yearly, it is likely that these

patients will walk into our offices (pre or post-surgery, or immediately post-injury). As manual therapists, trainers and sport therapists, it is necessary for us to be aware of the best way to progress a patient through an evidence-based rehabilitation protocol.

The authors of this clinical commentary provide an ACL rehabilitation program following reconstruction that is both progressive and evidence-informed.

PROGRAM SUMMARY

When possible, rehabilitation is typically initiated prior to surgery (pre-habilitation, if you will). To this end, these authors recommend a 21 day program in order to mentally and physically prepare the patient for surgery. During this time, it is important to reduce inflammation, swelling and pain, and to restore/achieve normal knee ROM as much as possible. Additionally, emphasis should be put on normalizing gait and preventing muscle atrophy. The authors recommend that full motion is restored prior to surgery to reduce the risk of post-operative arthrofibrosis (1) – a lofty and noble goal!

The post-surgical rehabilitation protocol is designed based on the type of surgical graft used, aiming to prevent loss of motion, reduce patellofemoral pain, graft failure, weakness and other complications. Generally, a patient who endured a semitendinosis graft surgery is progressed more slowly, so as to avoid graft laxity or surgical failure due to delayed or inappropriate healing time. Also, isolated hamstring exercises are avoided for at least 8 weeks to allow for proper healing in these cases.

The post-surgical phase begins with immediate passive knee ROM and weight bearing (WB) exercises. Knee extension ROM is emphasized at this stage, while flexion motion is gradually improved throughout the course of treatment. WB is to be performed as tolerated in a full-extension locked knee brace. The patient is then progressed to full WB without crutches after 10-14 days.

Subsequently, it is important to begin WB and non-WB activities, and exercises focusing on enhancing proprioception and strengthening. 2-3 weeks after surgery, neuromuscular control drills and perturbation training are gradually initiated to improve dynamic stability. Generally, more sport-specific activities such as running and cutting may be initiated 10-12 weeks and 16-18 weeks post-surgery, respectively. A gradual return to athletic competition is allowed approximately 6 months after surgery, once the patient can demonstrate 85% of contralateral strength in the quadriceps and hamstrings. Return to sports that emphasize jumping activities may be delayed to 6-9 months after surgical reconstruction.

ACL REHAB PRINCIPLES

Principles of ACL Rehabilitation

Full passive knee extension:
A lack of knee ROM, particularly in extension, is the most common complication following ACL reconstruction. Extension lag can result in abnormal joint kinematics, scar tissue formation and an increased incidence in patellofemoral/tibiofemoral joint contact and pain.

Extension can be augmented in a variety of ways, including supine hamstring and towel-assisted gastrocnemius stretching. Also, placing a heel wedge under the foot of the injured leg, while at the same time, (painlessly) placing 5-10 lbs of overpressure proximal to the patella can be performed. These stretches should be held for 15 minutes and should be performed 4 times daily. The amount of extension that should be restored is based on the un-injured knee.

Restoring Normal Flexion ROM:
Flexion ROM can be gradually improved by approximately 10°/week, which would allow for full flexion about 4-6 weeks post-surgery. Self-stretching, therapist or towel-assisted stretching can be employed here, in addition to soft tissue therapy directed at the anterior knee joint capsule and extensor mechanism. *(Writer's note: Restoring normal flexion ROM is important for athletes, especially power athletes such as sprinters, wrestlers, etc. Flexion is imperative throughout their gait cycle, as greater knee flexion facilitates faster translation of the lower limb through the saggital plane. Should this not be restored to pre-injury status, the athlete may never perform to the same perceived athletic level as pre-injury).*

Restoration of patellar mobility:
The loss of patellar mobility, also known as infrapatellar contracture syndrome, results in difficulty activating the quadriceps muscles and knee ROM compromise. This is especially apparent in individuals whose surgeons utilized a patellar tendon autograft. In this case, patellar mobilizations performed by the therapist are warranted. These mobilizations can be performed in the medial/lateral and superior/inferior directions to restore patellar tilting throughout ROM.

Reduction of postoperative inflammation:
It is intuitively important to control postoperative inflammation, pain and swelling during the early phase of rehabilitation. All can further increase the inhibition of the quadriceps, leading to more arthrokinematic problems (2). To do this, cryotherapy, high-voltage stimulation and joint compression using a sleeve, tensor wrap or some combination therein, can be employed.

In the second week post-surgery, slow progression to WB is also necessary to decrease pain and swelling. This can be done with two crutches with the knee locked into extension using a brace. The brace is worn until the quadriceps reach sufficient strength to enable a straight raise without a lag. The patient can then progress to one crutch, then to WB without crutches. This should be accomplished within 10-14 days post-surgery.

Re-establish voluntary quadriceps control:
Electromodalities (ex. Russian Stim) are often incorporated into an exercise program to activate the quadriceps during active contraction. It has been shown that combining stimulation with exercise is more efficient and superior to exercise alone for improving quadriceps strength post-surgery (3).This can be performed while performing isometric and isotonic exercises such as SLR, hip adduction and abduction, and knee extensions from 90-40°.

Neuromuscular control:
Within the second post-operative week, proprioceptive training can be performed, provided that pain and swelling are under control and quadriceps control has been re-established. Proprioceptive training is encouraged because it supposedly increases coactivation of the quadriceps and hamstrings, which improves overall knee stability. Training generally begins with exercises such as WB weight shifting (medial-lateral and/or diagonal directions), joint repositioning and box/potty-squats. Wearing an elastic support wrap while performing these exercises can be helpful, because it can augment the knee joint's position sense (4).

Provided that the patient can perform the mini-squats with good postural control, squats can be performed on an unstable surface at the end of the second post-operative week. The patient should squat to 25-30° while stabilizing the board for 2-3 seconds.

Once the patient reaches the third post-operative week, single-leg balance exercises performed first on flat ground, with slow progression to standing on a piece of foam with the knee slightly flexed can be performed. Later, these can be progressed to incorporate perturbation from the therapist, and/or concomitant upper and lower extremity movement. Once the patient becomes good at withstanding perturbation, medicine ball catching and throwing can be incorporated into their routine.

To retrain gait and enhance the dynamic stability of the knee, patients can perform forward, backward and lateral cone or cup step-over drills. The patient is encouraged to raise their knee to the level of the hip to step over the cone, and to land with a slightly flexed knee.

Lateral lunges should also be performed to improve neuromuscular control. The patient must step to the side and land with a slightly flexed knee and hold the position for 1-2 seconds, then return to the starting position. These can be progressed to diagonal lunges, lateral lunges with rotation and lateral lunges landing on foam. A ball toss can be incorporated to enhance the difficulty of any of these exercises, or elastic bands can be placed around the thigh or lower leg to increase hip stabilization (Gmed) stimulus.

It should be noted that squatting and lunging can be performed with a slight forward trunk tilt to recruit the hamstrings. This stabilizes the tibia from anterior saggital translation during movement, thus offloading the ACL. Additionally, limit the amount of distance the knee passes the toes during exercise to no greater than 8cm, as this can increase ACL loading as well.

Later on in the rehabilitation program (approximately 12 weeks post-patellar tendon autograft or 16 weeks post-semitendinosis autograft), plyometric training can be introduced to further enhance neuromuscular control. The authors suggest starting with the leg press machine, to control the amount of ground reaction force going through the injured/repaired joint. Then, the athlete can be progressed

to jumping on flat ground (ankle hops, jumping in place and lateral, diagonal and rotational jumping, etc), to jumping onto or off of boxes. The athlete is encouraged to land softly with the knees slightly flexed, and to begin with double-leg jumps, prior to progressing to single-leg jumps. It should be noted that plyometric training should only be used with competitive athlete. The risk of further injury is too high in any individual who does not participate in high-level competition.

Progression to sport-specific training and return to competition:
This is the last principle of post-surgical ACL rehabilitation. The patient is first asked to run in a pool or use an unloading treadmill prior to dry-land running to offload the knee. Backward and lateral running are recommended prior to forward running in order to decrease stress on the knee. Then, running and cutting drills, following by sport-specific agility drills can be performed. These activities are progressively introduced to the patient and are only done so provided that there is no regression in the patient's status.

The athlete's status can be tracked using various outcome measures, such as Cybex isokinetic muscle testing, the International Knee Documentation Committee Subjective Knee Evaluation form or the hop test. The authors recommend a specific return to play criteria which includes: satisfactory clinical examination, symmetrical ROM without pain, isokinetic testing (i.e. 80% or greater symmetric in the quadriceps, adequate hamstring-quadriceps ratio etc.) and a functional hop test showing the surgical leg performs within 85% or greater of the contralateral leg. Additionally, the patient must show confidence in their rehabilitation progress and have neither fear nor limitation while performing sporting activities.

Rehabilitation of the female athlete:
A discouraging increase in non-contact ACL injuries has begun to plague female athletes. Chief among explanatory theories is an increase in valgus stress with concomitant internal rotation of the tibia. Control over this biomechanical fault can be accomplished by first retraining the knee's dynamic movement pattern, by encouraging proper knee alignment with movement (i.e. knee over the second toe). Also, exercises such as front-step downs, lateral step-downs with resistance, squats with resistance around the distal femur (creating an internal rotation moment that the patient would have to overcome with relative external rotation force) and tilt-board variations can be utilized. All exercise should be performed with slight knee flexion – landing in full knee extension should be avoided.

These exercises all emphasize co-activation of the hamstrings and quadriceps, hip external rotators, abductors and core muscles. Special interest must be taken to eccentrically train the hip musculature to assist in controlling excessive adduction and internal rotation of the femur during weight bearing.

Exercise Timeline

Preoperative phase goals:

- Decrease inflammation, swelling and pain
- Restore normal ROM (especially extension)
- Restore voluntary muscle activation
- Provide patient education to prepare for surgery

Immediate post-operative phase goals (Days 1-7):

- Decrease joint swelling and pain
- Restoration of patellar mobility
- Slowly improve knee flexion
- Re-establish quadriceps muscle control
- Improve independent walking and standing

Early-rehabilitation phase goals (Weeks 2-4):
To enter this phase, the patient must have quadriceps control (as discussed above), full passive knee extension, passive ROM from 0-90°, good patellar mobility, minimal joint effusion and the ability to ambulate independently. Further objectives include:

- Maintain full passive knee extension
- Slowly increase knee flexion
- Continue to decrease swelling and pain
- Muscle training
- Proprioceptive training
- Patellar mobility

Controlled rehabilitation phase goals (Weeks 4-10):
To enter this phase, the patient must have active ROM from 0-115°, greater than 60% isometric quadriceps strength compared to the contralateral side, minimal-no joint effusion and no joint-line tenderness or patellofemoral pain. Further objectives include:

- Restore full knee ROM – (to 125°)
- Increase lower extremity strength
- Improve proprioception and neuromuscular control
- Increase muscular endurance
- Restore the athlete's confidence and knee function

Advanced activity phase goals (Weeks 10-16):
To enter this phase, the patient must exhibit AROM to 125°, greater than 79% isometric quadriceps strength compared to the contralateral side, a flexor-extensor ratio of 70-75%, neither pain nor effusion, satisfactory clinical examination, satisfactory isokinetic testing, ?80% of the distance achieved on the hop test compared to the contralateral leg and 80 points or higher on subjective knee scores. Also:

- Bring lower extremity strength to pre-injury levels
- Increase muscular power and endurance
- Increase neuromuscular control
- Progressively perform sport-specific drills.

After this, the athlete may endeavor to return to sport, as discussed above.

STUDY METHODS

This publication is a clinical commentary; a combination of evidence from the primary literature and the clinical experience of the authors. Neither statistical analysis, nor a description of their search process was included.

STUDY STRENGTHS / WEAKNESSES

The authors of this article have written a clinical commentary. No formal search strategy was discussed. Also, no statistical analysis was performed. Technically, opinion pieces are the lowest level of research quality. However, according to Sackett, treatment should be based on 3 pillars: the most current evidence, experience of the practitioner and patient treatment preference. The authors described their clinical process and backed it up with the best evidence available, which warrants integrating the contents of this article, or at least parts of it, into practice.

Additional References

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