Charles University
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Rehabilitation after Anterior Cruciate Ligament Reconstruction

BACHELOR THESIS

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Prague, 2011

Declaration

I declare that this Bachelor Thesis has been based entirely on my own individual work and on my own practice that took place in Central Military Hospital Prague (UVN) from 03/01/2011 till 14/01/2011. All the information used for the development of this Bachelor Thesis has been taken from the list of literature that exists in the end of this Thesis.

Prague, 2011 Tsaparegas Ilias

Acknowledgments

With this Bachelor Thesis I would like to thank:

God for keeping me safe during my study.

My family for their support.

My supervisor, Mgr. Miroslava Jalovcova, for her high level of knowledge during all my study years, help and guidance for the completion of this work.

My supervisor at Central Military Hospital Prague, Mgr. Romana Kozderkova, for her kindness, help and knowledge during the time I spent at the hospital for the thesis practice.

All the teachers at FTVS for their kindness, high level of knowledge and their efforts to pass them to their students.

Special thanks to Ass. Prof. Dr. Dagmar Pavlu, CSc.

All my colleagues and friends from FTVS for their co-operation. Special thanks to Iakovos Diogenous and Sant Sharker.

Abstract

Title: Rehabilitation after Anterior Cruciate Ligament (ACL) Reconstruction

Nazev: Kazuistika fyzioterapeuticke pece o pacienta s plastikou predniho zkrizeneho

Author: Ilias Tsaparegas

Aim: In this thesis, a therapeutic approach of ACL Reconstruction due to tendon rapture will be described and a complete therapeutic record of a patient after ACL Reconstruction is demonstrated.

Methods: The rehabilitation included 6 days of therapy. The main points of the state of the patient were light pain while walking, muscle weakness and incoordination, joint play restrictions and restriction of ROM of joints on the lower extremities. The first and last sessions with the patient included the Kinesiologic evaluation. Therapy and the methods which were used included joint play, strengthening exercises without and with the use of tools (like over-ball, Theraband, various balance boards, Posturomed platform, stationary bicycle, Stairmaster, soft pads), Isometric and Isotonic exercises, Post Isometric Relaxation (PIR), Proprioceptive Neuromuscular Fascilitation (PNF) techniques and Sensorimotor training.

Results: After 6 therapeutic units with the patient, she was able to walk with increased confidence and pain free at the knee joint. Mobilization of the restricted joint movements was successful and released the restrictions. The range of motion increased and the muscles on the operated leg also improved in strength and length. Muscle coordination and awareness of the body and lower limb positioning improved, resulting in better stability and minimizing the risk of future trauma of the same origin.

Key words: ACL Reconstruction, physiotherapy, proprioception, sensorimotor training.

Contents

1. Preface

This study was performed at Central Military Hospital Prague (UVN) as part of the Clinical Work Placement of the third year of Bachelor studies of Physical Therapy in FTVS – Charles University. It was consisted of 80 hours of total work divided in ten working days between the 3rd and 14th of January 2011.

The origin of research is a casuistic practice of a patient after Anterior Cruciate Ligament (ACL) Reconstruction after rapture using patellar tendon graft. It is divided into two parts: the general part and the special part.

The general part includes information about the knee joint. Anatomy, movements, pathological conditions, operation, complications and general guidelines of rehabilitation of ACL after reconstruction are stated in this part.

The special part is the practical approach of the diagnosis. It includes the anamnesis, the evaluation of the Initial Kinesiologic Examination, the rehabilitation plan, the rehabilitation procedures and the Final Kinesiologic Examination. Evaluation of the effect of the Therapy is next, stating the important changes after the therapeutic approach. The conclusion of the study follows containing the personal opinion about the experience of working with the patient with the particular problem.

2. General part

2.1 Introduction

The knee joint is one of the most vulnerable joints to damage because of the stresses to which it is subjected and because there is no interlocking of the articulating bones, stability is strictly applied by ligaments and tendons. Knee joint injuries are common because the knee is a mobile, weight-bearing joint, and its stability depends almost entirely on its associated ligaments and muscles.

The knee joint is essential for everyday activities such as standing, walking and climbing stairs. It is also a main joint for sports that involve running, jumping, kicking and changing directions. To perform these activities the knee joint must be mobile. However, this mobility makes it susceptible to injuries in contact and non-contact sports.

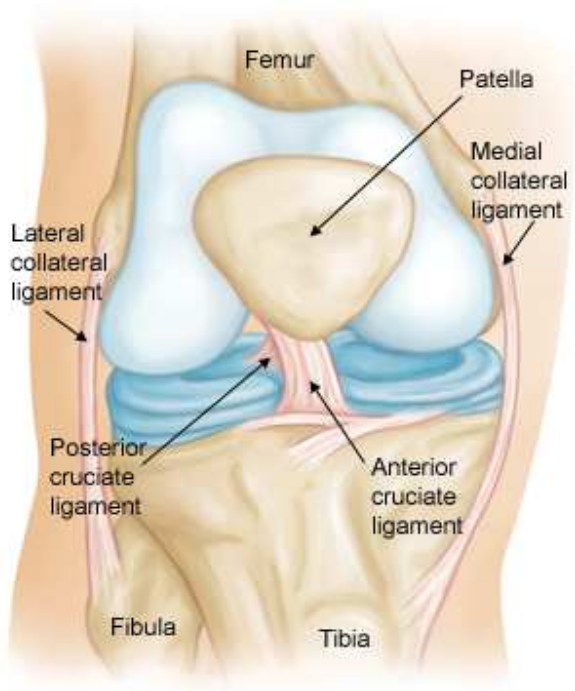
The most common knee injuries are ligament sprains, which occur when the foot is fixed in the ground. If a force is applied against the knee when the foot cannot move, ligament injuries are likely to occur. The tibial and fibular collateral ligaments normally prevent disruption of the sides of the knee joints. They are tightly stretched when the leg is extended and usually prevent rotation of the tibia laterally or of the femur medially. Because the collateral ligaments are slack during flexion of the leg, they permit some rotation of the tibia on the femur in this position. Severe force directed anteriorly with the knee semi-flexed may tear the Anterior Cruciate Ligament (ACL).

The function of the ACL is to provide stability to the knee and minimize stress across the knee joint: It restrains excessive forward movement of the lower leg bone (the tibia) in relation to the thigh bone (the femur) and it limits rotational movements of the knee.

ACL rupture is one of the most common knee injuries in skiing accidents, for example, allowing the tibia to slide anteriorly from the femur – this is also called the anterior drawer sign. The ACL may tear away from the femur or tibia. However, tears commonly occur in the mid- portion of the ligament.

2.1.1 Anatomy of Knee Joint

Anatomically, the knee is a hinge joint made up of three bones held firmly by ligaments that stabilize the joint (Picture 1). The bones that meet at the knee are the upper leg bone (the femur), the lower leg bone (the tibia), and the knee cap (the patella). A smooth protective layer called cartilage, which allows the bones to glide smoothly upon each other, lines the bones inside the joint. In arthritis, this smooth lining is damaged (2, 11, 14).



Picture 1 – Anatomy of the knee joint, frontal view
http://orthoinfo.aaos.org/topic.cfm?topic=A00549

2.1.2 Bones and Joints

The knee is the meeting place of two important bones in the leg: the femur and the tibia. A third component of the knee joint is the patella.

The knee joint is a synovial joint. Synovial joints are enclosed by a ligament capsule and contain a fluid, called synovium, which lubricates the joint.

The end of the femur joins the top of the tibia to create the knee joint. Two femoral condyles are found on the distal femur. These condyles rest on the top surface of the tibia at the tibial plateau.

The patella glides through a special groove formed by the two femoral condyles called the patellofemoral groove.

The smaller bone of the lower leg, the fibula, never really enters the knee joint. It does have a small joint that connects it to the side of the tibia. This joint normally moves very little.

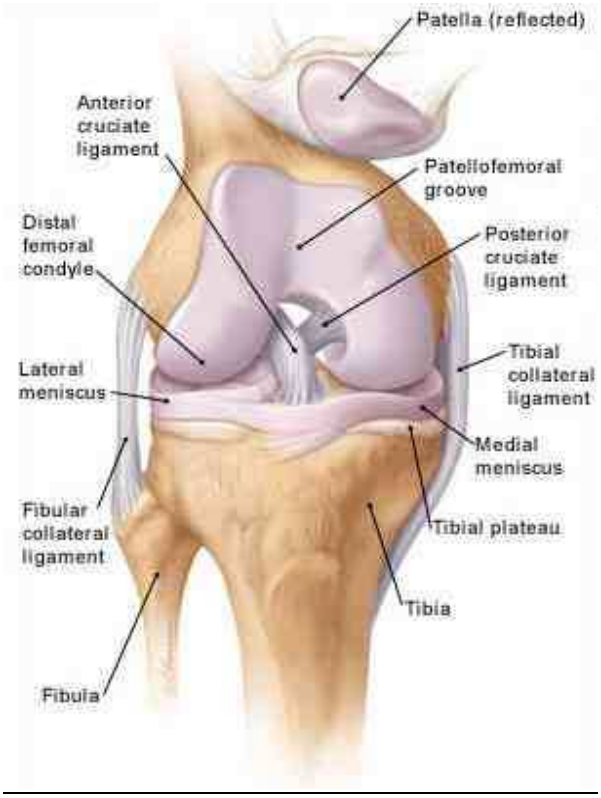
Articular cartilage is the material that covers the ends of the bones of any joint. It is a slippery substance that allows the surfaces to slide against one another without damage to either surface. The function of articular cartilage is to absorb shock and provide an extremely smooth surface to facilitate motion. It appears everywhere that two bony surfaces move against one another, or articulate. In the knee, articular cartilage covers the ends of the femur, the top of the tibia, and the back of the patella (2, 11, 14, 26).

2.1.3 Ligaments

Two major ligaments are found on either side of the knee joint. They are the medial collateral ligament and the lateral collateral ligament. These two ligaments prevent the knee from moving too far in the side-to-side direction.

Inside the knee joint, two other important ligaments stretch between the femur and the tibia: the anterior cruciate ligament in front, and the posterior cruciate ligament in back. These two ligaments control the front-to-back motion of the knee joint.

The Anterior Cruciate Ligaments keeps the tibia from sliding too far forward in relation to the femur. The Posterior Cruciate Ligament keeps the tibia from sliding too far backward in relation to the femur (Picture 2). The ligaments, all taken together, are the most important structures controlling stability of the knee (2, 11, 14).



Picture 2 – Ligaments of the knee

http://medchrome.com/basic-science/the-knee-joint/

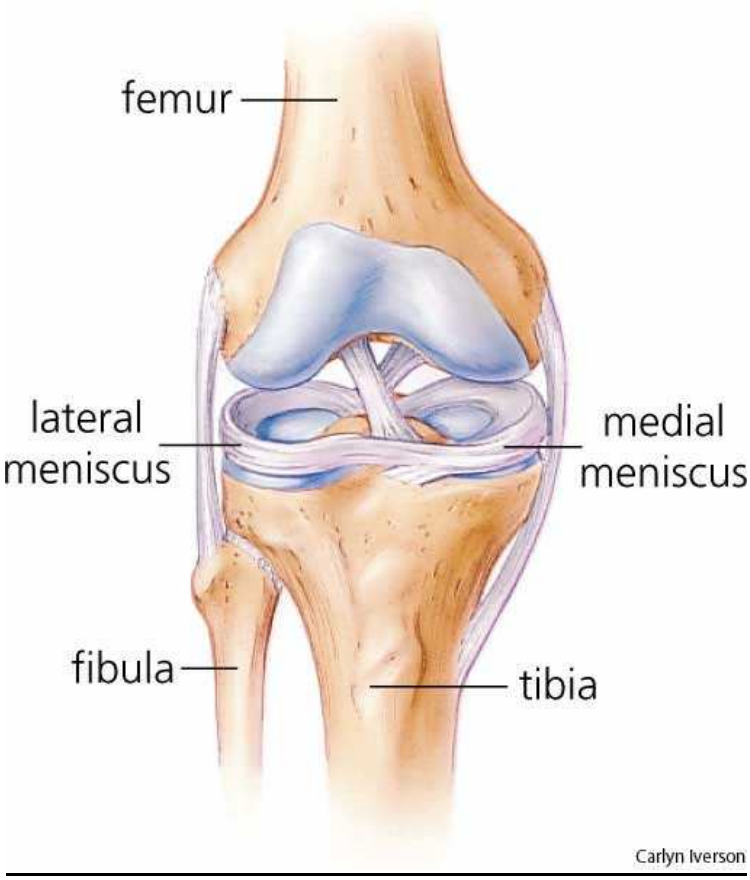
2.1.4 Menisci

Two menisci sit between the femur and the tibia. Sometimes referred to as the cartilage of the knee, the menisci differ from the articular cartilage that covers the surface of the joint (Picture 3).

The menisci are important because they work like a gasket to spread the force from the weight of the body over a larger area, and help the ligaments with stability of the knee. The menisci act like a gasket, helping to distribute the weight from the femur to the tibia spread out across the tibial surface. Weight distribution by the menisci is important because it protects the articular cartilage on the ends of the bones from excessive forces. Without the menisci, the concentration of force into a small area on the articular cartilage can damage the surface, leading to degeneration over time.

In addition to protecting the articular cartilage, the menisci help the ligaments with stability of the knee. The menisci are thicker around the outside, and this thickness helps to hold the round femur from rolling on the flat tibia.

The menisci convert the tibial surface into a shallow socket. The menisci enhance the stability of the knee and protect the articular cartilage from excessive concentration of force (2, 11, 14).



Picture 3 – Menisci of the knee

http://images.yourdictionary.com/meniscus

2.1.5 Tendons

The largest tendon around the knee is the patellar tendon (Picture 4). This tendon connects the patella to the tibia. It covers the patella and continues up the thigh.

It is called the quadriceps tendon since it attaches to the quadriceps muscles in the front of the thigh. The hamstring muscles on the back of the leg also have tendons that attach in different places around the knee joint. These tendons are sometimes used as tendon grafts to replace torn ligaments in the knee (2, 18, 14).

Picture 4 – Knee tendons
http://factotem.org/library/database/Knee-Articles/Knee-anatomy-physiology.shtml

2.1.6 Muscles

The knee joint has only two major functions which can be achieved by muscle function: extension and flexion. Both lateral bending and rotation movements are much reduced or even non-existing due to the knee structure. Therefore there are no muscles responsible for these two functions.

The extensor mechanism is the motor that drives the knee joint and allows us to walk. It sits in front of the knee joint and is made up of the patella, the patellar tendon, the quadriceps tendon, and the quadriceps muscles.

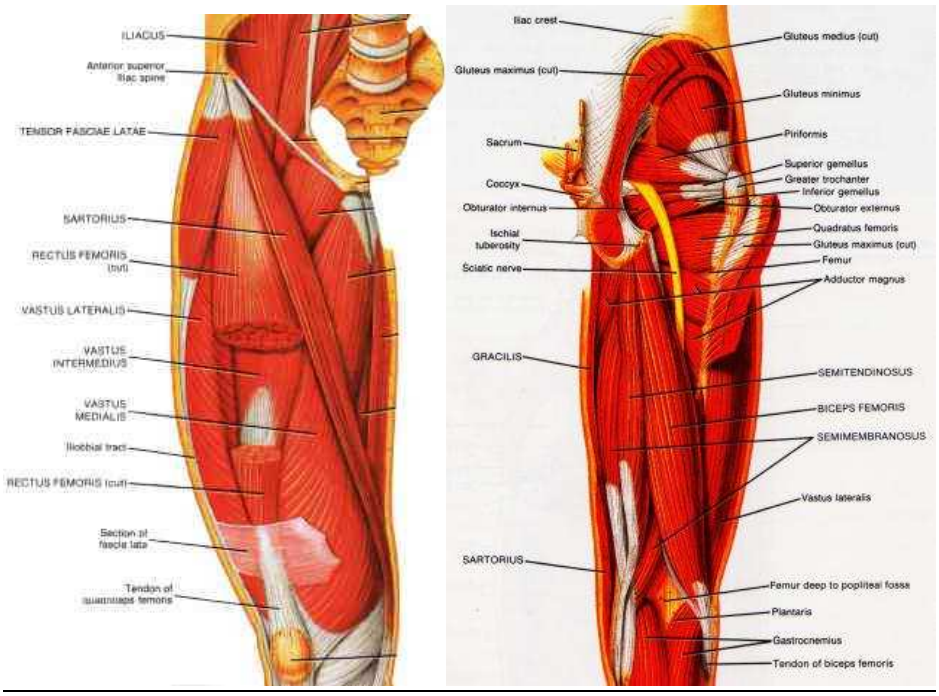
The four quadriceps muscles in front of the thigh are the muscles that attach to the quadriceps tendon (Picture 5). When these muscles contract, they straighten the knee joint, such as when someone gets up from a squatting position.

The way in which the kneecap fits into the patellofemoral groove on the front of the femur and slides as the knee bends can affect the overall function of the knee. The patella works like a fulcrum, increasing the force exerted by the quadriceps muscles as the knee straightens.

The flexor mechanism is composed mainly by the hamstring muscles which are the muscles in the back of the knee and thigh. When these muscles contract, the knee bends.

The principal muscles acting on the knee are: the extensors, comprised of the quadriceps femoris, the flexors, which include the hamstrings assisted by gracilis, gastrocnemius and Sartorius, and the internal rotators, including the popliteus muscle that rotate the knee in a non-weight bearing position.

Additional muscles involved in isolated knee flexion include the gastrocnemius and plantaris muscles (2, 11, 14).



Picture 5 – Knee Muscles
(Left: Anterior view, Right: Posterior view)
http://www.mountain-bike-cumbria.co.uk/articles.php?id=kneeinjuries

2.1.7 Nerves

The major functions of the knee joint, flexion and extension, are innervated by both the femoral and sciatic nerve. Injury to these nerves will cause impairment in the performance of flexion and/or extension of the knee joint as well as loss of sensation on the lower limb.

Other nerves go around or through the knee. The popliteal nerve is in the back of the knee. This large nerve travels to the lower leg and foot, supplying sensation and muscle control. The nerve splits just above the knee to form the tibial nerve and the peroneal nerve. The tibial nerve continues down the back of the leg while the peroneal nerve travels around the outside of the knee and down the front of the leg to the foot. Both of these nerves can be damaged by injuries around the knee (2, 11, 14).

2.1.8 Blood Vessels

The major blood vessels around the knee travel with the popliteal nerve down the back of the leg. The popliteal artery and popliteal vein are the largest blood suppliers to the leg and foot. If the popliteal artery is damaged beyond repair, it is very likely the leg will not be able to survive. The popliteal artery carries blood to the leg and foot. The popliteal vein carries blood back to the heart (2, 11, 14).

2.1.9 Bursa

Various bursas are located around the knee joint for purposes of decreasing friction over tendons and bones. The suprapatellar bursa is located between the deep surface of the quadriceps muscle and the distal part of the femur. The prepatellar bursa is located between the superficial surface of the patella and the skin. An infrapatellar bursa is located between the patellar ligament and the skin. The deep infrapatellar bursa is situated between the proximal tibia and the patellar ligament. Other bursas decrease friction at the attachment sites of the gastrocnemius, gracilis, sartorius, semitendinosus, and semimembranosus muscles(2, 11, 14).

2.2 Movements of the knee

The principal knee movements are flexion and extension, but some degree of rotation of the knee is possible when this joint is in the flexed position. In full extension, i.e. in the standing position, the knee is quite rigid because the medial condyle of the tibia, being rather larger than the lateral condyle, rides forward on the medial femoral condyle, thus ‘screwing’ the joint firmly together. The first step in flexion of the fully extended knee is ‘unscrewing’ or internal rotation.

This is brought about by popliteus, which arises from the lateral side of the lateral condyle of the femur, emerges from the joint capsule posteriorly and is inserted into the back of the upper end of the tibia.

As mentioned, the principle motions of the knee joint are flexion and extension; however, it does allow for some degree of rotation. The range of motion of the knee is about 0° extension to 140° of flexion.

The amount of internal and external rotation about the knee is approximately 5° to 10° in each direction. It is in extension that the rotational component of the knee joint is necessary. The knee is unable to reach full extension without a small amount of external rotation of the tibia on the femur. This need for external rotation is due to the fact that the medial femoral condyle is approximately 1/2-inch longer than the lateral femoral condyle. The external rotation of the tibia allows the knee to achieve full extension. This mechanism is known as the "lock" mechanism and it allows the knee to be held in full extension without undue fatigue of the surrounding musculature (2, 11, 14).

2.3 ACL Biomechanics

The ACL is the primary restraint (85%) to limit anterior translation o f the tibia. The greatest restraint is in full extension. The ACL also serves as a secondary restraint to tibial rotation and varus/valgus angulation at full extension. Since the relationship between the tibia and femur provides little bony stability, the ligamentous structures must provide stability. When the ACL is injured, a combination of anterior translation and rotation occurs. The average tensile strength for the ACL is 2160 Newtons. This is slightly less than the strength of the posterior cruciate ligament and approximately half as strong as the medial collateral ligament.

The mechanism of stabilization of the joint varies according to whether it is slightly flexed or hyper extended. When the knee is straight and very slightly flexed, the force exerted by the body weight acts behind the flexion and extension axis of the knee and so the knee tends to flex further unless prevented by contraction of the quadriceps. Therefore, in this position the quadriceps is essential for the maintenance of the erect posture.

On the other hand, when the knee is hyper extended, the natural tendency for this hyperextension to increase is soon checked by the capsule and the related ligaments posteriorly, so this erect posture can be maintained without the quadriceps.

Passive knee extension produces forces along ACL only during last 10 degrees of knee extension.

During Hyper-extension:

- The posterolateral bundle of the ACL is tight in extension.
- At 5 degrees of hyperextension, anterior cruciate ligament forces range between 50 and 240 newtons.
- Hyperextension of the knee develops much higher forces in ACL than in the PCL.

During Flexion:

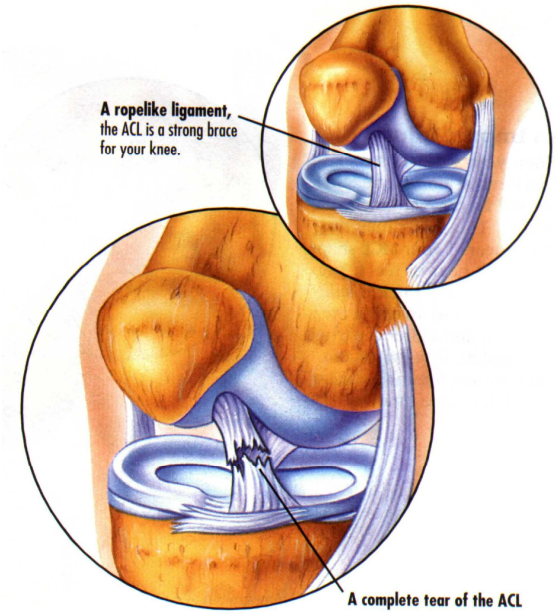
- The anteromedial bundle of the ACL is tight in flexion.
- During isometric quadriceps contraction, ACL strain at 30° of knee flexion is significantly higher than at 90° where ligament remains unstrained with isometric quadriceps activity.
- Active flexion of knee between the limits of 50 and 110 degrees does not strain the anterior cruciate.
- At 90° of knee flexion, ACL accounts for approx 85% of resistance to anterior drawer test. (4), (9)

2.4 Clinical State of ACL's rapture

An injured anterior cruciate ligament reduces stability in the knee and decreases support of the knee joint during athletic activity. Injuries can vary in severity, ranging from minor sprain to a complete tear or rupture of the ligament (Picture 6). Symptoms of an ACL tear include: pivot shift episodes, pain, and feeling a 'pop.' On physical exam, the physician usually finds an effusion, a positive anterior drawer sign, a positive Lachman's test, and/or a positive pivot shift test.

General signs and symptoms of anterior cruciate ligament rupture are:

- Considerable pain in the knee that does not go away within the first few hours after the injury.
- Immediate (usually within 24 hours) swelling of the knee (hemarthrosis).
- A feeling of unsteadiness and a tendency for the knee to "give-way".
- An inability to bear weight on the injured leg.
- An audible "pop" or the perception of something snapping or breaking at the moment of injury.
- A feeling of "fullness" or "tightness" in the knee (3, 16).



Picture 6 – Torn ACL
http://www.athleticadvisor.com/Injuries/LE/Knee/torn_acl.htm

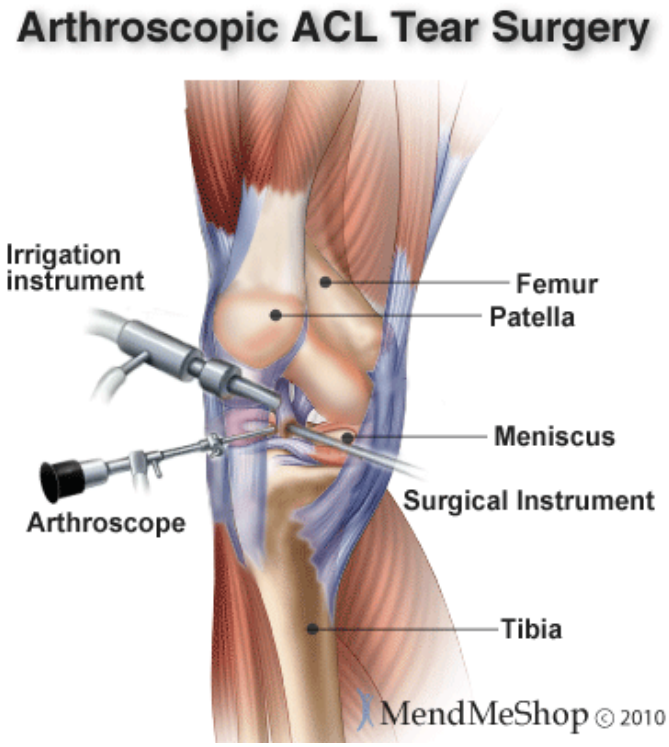
2.5 Diagnosis of ACL Rupture

Diagnosis of ACL rapture can be assessed:

- Thought imaging methods:
  - X-rays
  - Magnetic Resonance image (MRI)
  - Computed Tomography (CT)
- Through arthroscopy.
- Through medical tests.

Arthroscopy

Arthroscopy is a surgical procedure orthopedic surgeons use to visualize, diagnose, and treat problems inside a joint (Picture 7). In an arthroscopic examination, an orthopedic surgeon makes a small incision in the patient's skin and then inserts pencil-sized instruments that contain a small lens and lighting system to magnify and illuminate the structures inside the joint. Light is transmitted through optic fibres to the end of the arthroscope that is inserted into the joint. Through the arthroscope, a final diagnosis is made, which may be more accurate than through "open" surgery or from X-ray studies (17, 20).



Picture 7 – Knee arthroscopy
http://www.mendmyknee.com/_img/arthroscopic-acl-tear-surgery.gif

Lachman's Test.

Lachman's test is a medical test used for examining the ACL in the knee for patients where there is a suspicion of rapture. The Lachman test is recognized by most authorities as the most reliable and sensitive clinical test for the determination of anterior cruciate ligament integrity. The original description provided for the test is reported as either positive or negative. With the knee flexed 20–30°, the tibia is displaced anteriorly relative to the femur (Picture 8). A soft endpoint or greater than 4 mm of displacement is positive (abnormal).The criteria are as follows:

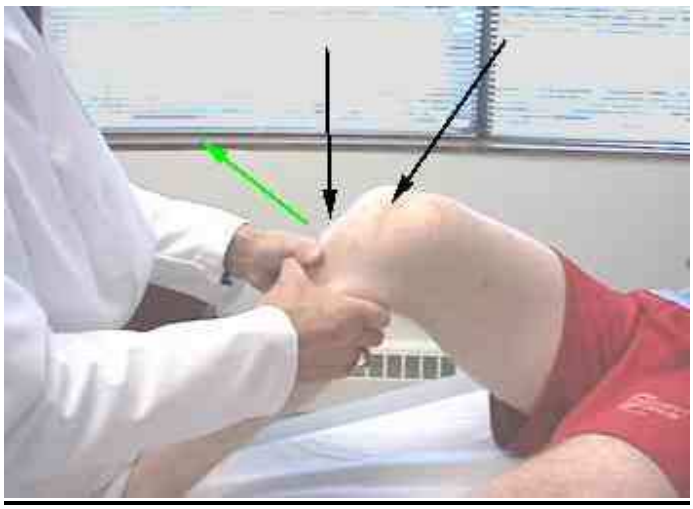
- Grade I, proprioceptive appreciation of a positive test
- Grade II, visible anterior translation of the tibia;
- Grade III, passive subluxation of the tibia with the patient supine; and
- Grade IV, ability of the patient with a cruciate deficient knee to actively sub – luxate the proximal tibia.

Picture 8 - Lachman's test

http://www.sportsdoc.umn.edu/Clinical_Folder/Knee_Folder/Knee_Exam/lachmans.htm

Anterior Drawer test

The drawer test is used by providers to detect rupture of the cruciate ligaments in the knee. The patient should be supine with the hips flexed to 45 degrees, the knees flexed to 90 degrees and the feet flat on table (Picture 9). The examiner sits on the patient's feet and grasps the patient's tibia and pulls it forward (anterior drawer test) or backward (posterior drawer test). If the tibia pulls forward or backward more than normal, the test is considered positive. The Lachman test is a variation on this test in which the knee is in 30° (thirty degrees) of flexion.

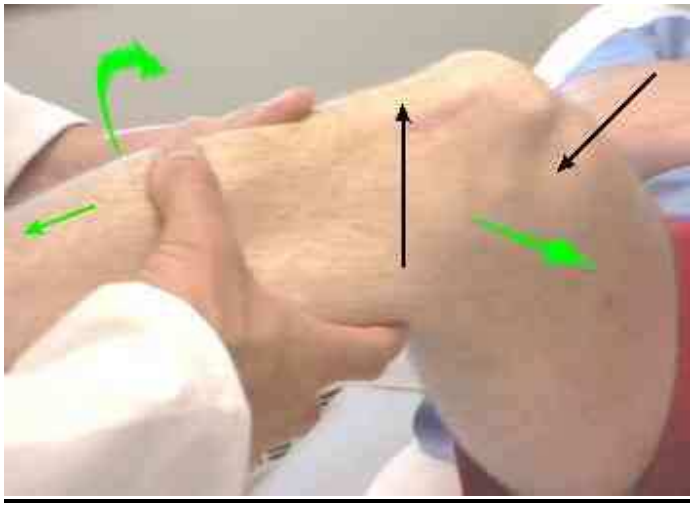


Picture 9 – Anterior drawer test
http://www.sportsdoc.umn.edu/Clinical_Folder/Knee_Folder/Knee_Exam/anterior%20drawer.htm

Pivot Shift Test

Another effective test, for detection of anterior cruciate ligament rupture, is pivot shift test. The patient is positioned supine, with the examiner standing on the affected side. The examiner uses one hand to hold the patient's foot in very slight internal rotation (Picture 10). With the other hand, (s)he applies a valgus stress to the

posterolateral aspect of the proximal calf. At this point, flexion is started. The lateral tibial plateau will be seen to subluxate forward during the first degrees of flexion. As flexion progresses, the anterolaterally subluxated tibia will suddenly reduce at 30° of flexion. This reduction is associated with a characteristic clunk, which the patient will readily recognize.



Picture 10 – Pivot shift test
http://www.snowclub.gr/forums/lofiversion/index.php/t4923.html

Pivot-shift test (by Dejour's)

The patient's foot is wedged between the body and the elbow of the examiner. The examiner places one hand flat under the patient's tibia, pushing it forward (force applied in an anterior direction), with the knee in extension. The other hand is placed against the patient's thigh, pushing the other way (force applied in a posterior direction). The lower limb is taken into slight abduction, by the examiner's elbow, with the examiner's body acting as a fulcrum to produce valgus. The examiner maintains the anterior tibial translation and the valgus, and imparts flexion. At 20°-30° flexion, pivot shifting will occur, with a clunk as the lateral tibial plateau suddenly reduces.

Note: The valgus stress associated with the anterior tibial drawer makes the lateral

tibial plateau sublux on the lateral femoral condyle and compresses the structures. The sudden reduction of the convex lateral tibial plateau compressed under the lateral condyle is responsible for the clunk. Sometimes, a clunk may be elicited with compression, rather than any major valgus stress. The pivot shift is easy to produce, and causes no discomfort. It is a mixture of shift and Lachman, and provides evidence of ACL tears and damage to posteromedial structures (16, 1, 12, 23, 15).

2.6 Causes of ACL Rupture

Hormonal:

- Due to estrogen deficiency.

Anatomic:

- ACL size.
- Intercondylar notch.
- Lower-leg alignment.
- Knee joint laxity.
- Muscle flexibility.

Environmental:

- Playing style.
- Shoe-surface interface.
- Uneven playing surface.

Anatomic Factors:

Intercondylar notch: Impingement of the ACL against the intercondylar notch has been proposed as a possible anatomic cause of ACL injuries. An ACL lodged in a narrow A-shaped notch, instead of a reverse U-shaped notch, may experience greater shearing forces against the bone. The ACL impinges on the medial border of the lateral

femoral condyle with valgus stress. It has been demonstrated that the ACL contacts the anterior intercondylar notch when the knee is in full extension. Computed tomography (CT) analysis of patients with bilateral ACL injuries has revealed a narrower intercondylar notch in injured patients when compared with the intercondylar notch of controls.

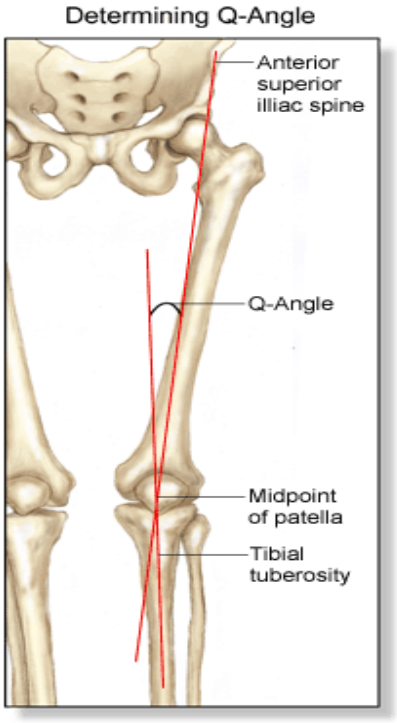
Environmental Factors

Several environmental parameters have been assessed as possible contributors to ACL injury. For example, a higher rate of ACL injuries has been reported in athletes who wear cleats that are placed at the peripheral margin of the sole with a number of smaller pointed cleats positioned interiorly. This cleat arrangement resulted in a higher torsional resistance than the other cleat designs.

An uneven playing surface, such as bumpy grass fields, may also pose a threat to the ACL. In one study of ACL injury mechanics, many patients reported landing or stepping on an uneven surface at the time of the accident. The unexpected foot position may alter knee motor recruitment patterns, placing the ACL at risk of rupture.

Other factors

A wider pelvis and greater average Q-angle have been postulated to contribute to ACL disruption by placing the knee in a more valgotic or unstable position. The Q-angle is the angle formed between the longitudinal axis of the femur, representing the line of pull of the quadriceps muscle, and a line that represents the pull of the patellar tendon (Picture 11). When the quads are relaxed, the Q-angle is normally less than 15 degrees in men and less than 20 degrees in women. An abnormally large Q-angle usually results in a disorder called abnormal quadriceps pull. When the quadriceps muscle contracts, it pulls the kneecap sideways resulting in an over-pronation and internal rotation which can lead to knee problems.



Picture 11 – The Q angle

http://www.leadingmd.com/virtual/education/assets/q_angle.gif

Usual causes of rapture

A tear to the anterior cruciate ligament (ACL) results from overstretching of this ligament within the knee. It is usually due to a sudden stop and twisting motion of knee, or a force or "blow" to the font of the knee. The extent of the tear can be partial or a complete tear (21, 9).

Most ACL injuries occur during athletic activity. Often those are non-contact activities with the mechanism of injury usually involving:

- Planting and cutting: The foot is positioned firmly on the ground followed by the leg (and body as well) turning one direction or the other. Example: Football player making a fast cut and changing direction.
- Straight-knee landing: Results when the foot strikes the ground with the knee straight. Example: Basketball player coming down after a jump.

- One-step-stop landing with the knee hyper extended: Results when the leg abruptly stops while in an over-straightened position. Example: Baseball player sliding into a base with the knee hyper extended with additional force upon hyperextension.
- Pivoting and sudden deceleration resulting from a combination of rapid slowing down and a plant and twist of the foot placing extreme rotation at the knee. Example: Football or soccer player quickly slowing down followed by a quick turning direction (16, 1, 21, 12, 23).

2.7 Treatment of ACL rapture

2.7.1 Non- surgical treatment

Surgical treatment is usually in dealing with combined injuries (ACL with other injuries in the knee). However, deciding against surgery is a reasonable selection for patients. Non-surgical management of isolated ACL tears is likely to be successful or may be indicated in patients:

- With partial tears and no instability symptoms.
- With complete tears and no symptoms of instability during low-demand sports.
- Who are willing to give up high demand sports.
- Who do light manual work or live sedentary lifestyles.
- Whose growth plates are still open (children).

In non-surgical treatment, progressive physical therapy and rehabilitation can restore the knee to a condition close to its pre-injury state and educate the patient on how

to prevent stability. This may be supplemented with the use of a hinged knee brace. However, many people who choose not to have surgery may experience secondary injury to the knee due to repetitive instability episodes.

For a patient following a non-surgical treatment, precautions are necessary like:

- Modification of active lifestyle to avoid high demand activities.
- Muscle strengthening exercises and proprioception exercises.
- May require knee brace (16, 17, 20, 10).

2.7.2 Surgical treatment

At present, reconstruction is usually done without an open knee surgery. It is performed with arthroscopic assistance and running a graft through reamed tunnels in the tibia and femur. The graft is generally anchored at both ends. Graft materials are more often harvested from the patient, but cadaver grafts are still used in selected patients. Prior to graft placement, the existing torn ACL must be arthroscopically removed from the knee thoroughly.

Arthroscopy is a minimally invasive surgical procedure in which an examination and sometimes treatment of damage of the interior of a joint is performed using an arthroscope, a type of endoscope that is inserted into the joint through a small incision. Arthroscopic procedures can be performed either to evaluate or to treat many orthopedic conditions including torn ACL and reconstruction. The advantage of arthroscopy over traditional open surgery is that the joint does not have to be opened up fully. This reduces recovery time and may increase the rate of surgical success due to fewer traumas to the connective tissue (16, 17, 1, 20, 10, 22).

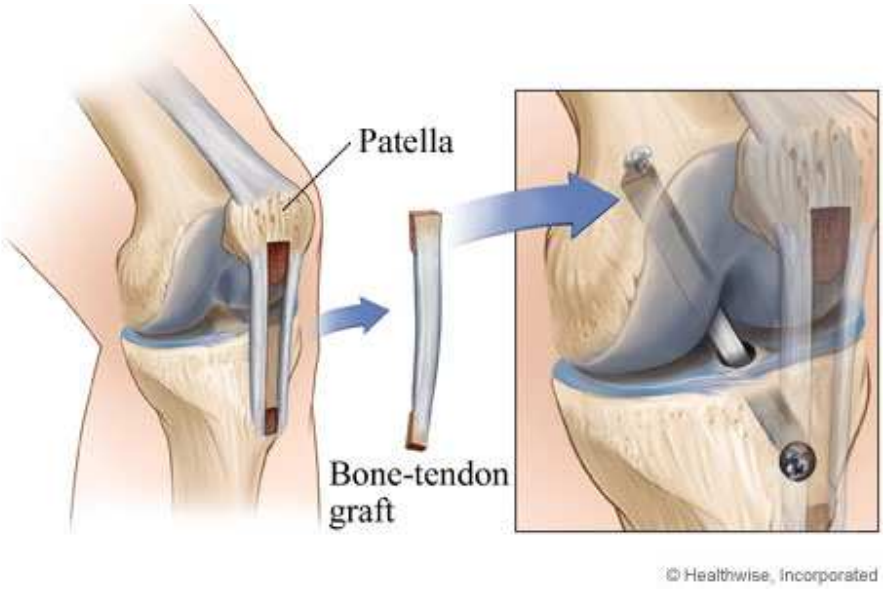
2.7.3 Surgical Techniques of ACL Reconstruction

ACL tears are not usually repaired using suture to sew it back together, because repaired ACL has generally been shown to fail over time. Therefore, the torn ACL is generally replaced by a suitable graft made of tendon. The grafts commonly used to replace the ACL include:

- Patellar tendon autograft.
- Hamstring tendon autograft.
- Quadriceps tendon autograft or allograft (takes from a cadaver) patellar tendon.
- Anchille's tendon, semitendinosous, gracilis or posterior tibialis tendon.

One common technique of reconstruction uses a central third **patellar-tendon autograft**. The middle one third of the ipsilateral patellar tendon is harvested with bone plugs from the patella and tibial tuberosity. The graft is inserted through femoral and tibial tunnels. It is often secured by two metal or absorbable interference screws.

Another method of reconstruction, uses a **double loop graft of semitendinous and gracilis tendons**. In this procedure, portions of the hamstring tendons are dissected from their muscular insertion. Their bony insertion remains intact. The graft is then pulled through the tunnels and looped back over an Endobutton (like a pin) in the femur, thus becoming a double loop. The lower portion is secured with a screw in the tibia. The screw is a metal flat washer (like a button) attached to a loop of polyester tape through which the graft is run (19, 16, 1, 20, 10).



Picture 12 - ACL Reconstruction surgery
http://www.webmd.com/hw-popup/bone-and-knee-tissue-graft-for-acl-surgery

2.7.4 Causes of ACL Reconstruction complications

Causes of graft failure can be divided into three categories: technical, biologic, and external.

Technical causes include non-anatomic tunnel placement, graft failure, bone plug fracture, inadequate notchplasty, improper tensioning, graft fixation, and insufficient graft material. Plain x-rays can be used to evaluate fracture of the bony portions of the grafts, metallic screw integrity and position, union of the bony portions of the graft, tunnel placement, and size of screw tunnels. Magnetic Resonance can also be used to evaluate tunnel positioning, graft integrity and other soft tissues of the knee.

Biologic causes for failure include failed ligamentization (for those grafts which were not originally ligaments), infection, arthrofibrosis, and infrapatellar contracture syndrome.

External causes for failure include traumatic rupture, secondary instability of the knee, and improper rehabilitation (10, 16, 17, 20).

2.7.5 Complications of ACL Reconstruction surgery

ACL reconstruction surgery is generally safe. Complications that may arise from surgery or during rehabilitation and recovery include:

- Numbness in the surgical scar area.
- Infection in the surgical incisions.
- Damage to structures, nerves, or blood vessels around and in the knee.
- Blood clots in the leg.
- The usual risks of anesthesia.
- Problems with the graft tendon (loosening, stretching, reinjury, or scar tissue).
- The screws that attach the graft to the leg bones may cause problems and require removal.
- Limited range of motion, usually at the extremes.
- Grating of the patella as it moves against the lower end of the femur may develop. This may be painful and may limit the patient's performance.
- In rare cases, the patella may be fractured while the graft is being taken during surgery or from a fall onto the knee soon after surgery.
- Pain, when kneeling, at the site where the tendon graft was taken from the patellar tendon or at the site on tibia where a hamstring or patellar tendon graft is attached.
- Repeat injury to the graft (just like the original ligament). Repeat surgery is more complicated and less successful than the first surgery (10, 16, 17, 20).

2.8 Physiotherapy after ACL Reconstruction

2.8.1 Pathological post- operative physiotherapeutic findings

The ACL is thought to play an important proprioceptive role in knee stability. When it is damaged, there is a loss of afferent information necessary for the ideal muscle function. This results in decreased muscle coordination and loss of balance ability. Due to reports, 79% of patients with ACL reconstruction, have tight iliotibial band and weak hip abductors. Also, the altered muscle activation was with increased EMG activity of the hamstrings and quadriceps inhibition.

After ACL injury, strength and balance can be improved with sensorimotor training. It has been found to be more effective than strength training in restoring neuromuscular function (3, 8, 9, 6, 24, 13).

2.8.2 Phases of rehabilitation

The rehabilitation of ACL after Reconstruction is divided in 4 Phases and the goals for each phase are the following (3, 9, 12, 24, 22):

1st Phase – weeks 1-2

In the first one to two weeks, the aims of therapy are to decrease pain and swelling and increase the range of motion of the knee. A post-operative brace is ranged from 30° to 90° and is used until there is adequate quadriceps control. Physiotherapy including Continuous Passive Movements device (CPM) is used immediately post operatively. In this early phase there is an emphasis on isometric contraction of the hamstrings and co-contractions of the hamstrings and the quadriceps. Crutch -walking with partial weight bearing is allowed and the usual modalities are used to reduce pain and swelling.

2nd Phase – weeks 3-6

During the second phase, from three to six weeks, the emphasis is on increasing the range of motion, increasing weight bearing and gaining hamstring and quadriceps control. The patient is usually out of the brace by the third to fourth week. During this phase, gait re-education and static proprioception exercises commence. This may include balancing on the affected leg, biofeedback techniques and swimming to maintain conditioning and range of motion.

3rd Phase – weeks 6-12

During the third stage, from six to twelve weeks, emphasis is placed on improved muscular control, proprioception and general muscular strengthening. Proprioceptive work progresses from static to dynamic techniques including balance exercises on the wobble board and other devices and eventually jogging on a mini-tramp. The patient should have a full range of motion during this stage and gentle resistance work should be added. By the end of this period the patient should be able to cycle normally, swim with a straight leg kick and be able to jog freely on the mini-tramp.

4th Phase – weeks 12- 6 months

The fourth phase of rehabilitation from twelve weeks to six months involves the gradual re-introduction of sports specific exercises aimed at improving agility and reaction times and increasing total leg strength.

2.8.3 Prognosis

Patients treated with surgical reconstruction of the ACL have long-term success rates of 82-95%. Recurrent instability and graft failure is seen in approximately 8% of patients. Knee scores of those treated non-operatively have fair/poor results up to 50% of the time. As many as 40% of patients treated non-operatively, had no episodes of giving way. The knee scores in this group may be too sensitive, not accurately representing the clinical situation. Patients with ACL ruptures, even after successful reconstruction, are at risk for osteoarthrosis. The goal of surgery is to stabilize the knee, decrease the chance of future injury and delay the arthritic process (17, 20).

3. Special Part

3.1 Methodology

The clinical practice on which this special part of the thesis is based, was held during a two-week period from Monday the 3rd of January 2011 to Friday the 14th of January 2011, at Central Military Hospital Prague (UVN), Czech Republic.

UVN rehabilitation department is an in-patient and out-patient rehabilitation clinic, offering treatment to patients who suffer from a variety of disorders. There is a fully equipped hydrotherapy and electrotherapy department as well as a gym room equipped with tools as weights, mattresses, over balls, bosu stability balance balls, soft pads, a stepper, a bicycle and a stability platform.

The patient, in the specific period, was in a state of anterior cruciate ligament reconstruction after being operated two months ago (on 27.10.2010) because of rapture of this ligament. After the operation, she was indicated for physical therapy. The author of this thesis was the responsible physiotherapist for two weeks and physiotherapy was given as described in the following special part. The rehabilitation program included six therapeutic units which lasted 30 minutes apart from the first and last which lasted for 1 hour in order to provide the initial and final kinesiologic examination.

Therapy and the methods which were used included joint play, strengthening exercises without and with the use of tools, Isometric and Isotonic exercises, Post Isometric Relaxation (PIR), Proprioceptive Neuromuscular Fascilitation (PNF) techniques and Sensorimotor training.

Tools and equipment used during the two weeks was a goniometer, a measure tape, a pinprick, a metal ruler for temperature sensation, a theraband, wobble and rocker boards, soft pads, stationary bike, stairmaster and Posturomed platform.

An informed consent and approval of the project of this thesis by the Ethics Committee of the Faculty of Physical Education and Sport at Charles University exist at the Supplements section of the thesis.

3.2 Anamnesis

Name: A.S., female

Date of birth: 1970

Diagnosis:

ACL reconstruction (patellar tendon graft) - right knee.

- **Personal anamnesis**

➢ Childhood diseases:

- Typical childhood diseases.

➢ Operations:

- 1980 - operation for fractured tibia, right leg.
- 1999 - contusion of the knee, right leg.
- 2000 and 2004 – Caesarean section for baby delivery.

➢ Allergies: No.

➢ Abuses:

- Non smoker.
- Drinks alcohol socially.
- Drinks 2-3 coffees/ day.

➢ Gynecological anamnesis:

- 1st menstruation when she was 14 year old.
- In 2000 and 2004 gave birth with caesarian section.
- In 2003 had spontaneous abortion.

➢ Pharmacological anamnesis:

- Yasminelle 0,02mg/3mg.

➢ Other injuries/disorders:

- Myopia and astigmatism since 1979.

- **Family anamnesis**

- Father was born in 1938. Has Parkinson disease and heart arrhythmia.
- Mother was born in 1943. She is healthy.
- Brother was born in 1978. He is healthy.
- She has a son and a daughter. Both are healthy.

- **Social anamnesis**

- Married, lives with her family at a block of flats with elevator.
- Skiing, bicycling and running are her favorite sports.

- **Work anamnesis**

- Works as a doctor (gastroenterologist) at UVN. At her workplace she has to walk and stand a lot daily but does not have to carry any heavy things.
- Also, at her workplace, she has to climb up and down an unknown number of stairs.

- **Medical anamnesis**

- On 08.03.2010 while skiing in Austria, she had an accident and her right lower leg rotated. She had intensive pain and was feeling instability of the right knee joint. Her knee started swelling and was transferred to an Austrian hospital where she was submitted to puncture of the hemarthrosis. Then cooling cream and brace was placed at the knee joint. Anti embolism therapy was prescribed, the patient

had to use crutches and returned to Prague.

- On 12.03.2010 puncture of the hemarthrosis was repeated at UVN.
- MRI was provided the same date for the right knee joint which showed rapture of the anterior cruciate ligament.
- Examination by the doctor also showed that the patient could move without the orthesis but was noted instability of the knee joint.
- Further medical examinations noted that the patient cooperates, has no ikterus or cyanosis of head or neck, peripheries are in normal condition and the innervations are normal.
- The patient was submitted to fixation with knee brace for 6 weeks. She was advised for the next few months to treat her knee conservatively in order the swelling will go away and any possible micro traumas will heal. Also, she was advised to strengthen her lower extremities' muscles following a mild 9 week rehabilitation program and wait for operation on the right knee joint of anterior cruciate ligament.
- On 19.10.2010 she was called for preoperative examinations and was found capable to go under anesthesia and operation of the knee.
- On 27.10.2010 she was operated on the right knee for the raptured cruciate ligament. Patellar tendon graft was used to replace the ruptured ligament and was fixated using screws made of non magnetic material. There were no complications after the operation. Medications against infection and pain were offered. Rehabilitation started immediately and with verticalization of the patient on the 1st day after operation.

Previous rehabilitation

Patient was submitted to physical therapy immediately after the surgery for ACL reconstruction on 27. 10.2011. During the 9 post operative weeks until now, her rehabilitation involved:

- Edema reduction.
- Scar treatment.
- Muscle strength improvement for the weak muscles.
- Relaxation for shortened or hypertonic muscles.
- ROM improvement.
- Gradual weight bearing increase.
- Posture correction.
- Proprioceprion and gait improvement.

Indication of Rehabilitation:

- Active exercises in whole ROM for the operated knee
- Full weight bearing.
- Strengthening exercises against light to moderate resistance for the lower extremities' muscles with focus on the operated leg.
- Promote muscle coordination for lower extremities.
- Promote body core stability.
- Promote endurance exercises.
- Promote functional strengthening exercises

3.3 Initial Kinesiologic Evaluation (03.01.2011)

Present state:

- Weight: 57 kgr.
- Height: 160cm
- BMI: 22,3 kgr/m2
- After ACL Reconstruction on the right knee, 9 weeks after operation.
- Main complaint is intermittent pain of grade 3 (0-10 scale), as stated, in the operated knee during walking.
- Does not use crutches.
- Does not use knee brace.
- Patient is well orientated and concentrated.

3.3.1 Postural examination

Table 1 - Posterior view

Heel form and position	Symmetrical
Achille's tendon contour	Asymmetrical - Left tendon contour is bigger
Achille's tendon shape	Both face laterally - convex
Calves	Asymmetrical - Hypotrophy on right side
Popliteal lines	Same level
Thigh contour	Asymmetrical – Hypotrophy on right side
Gluteal muscles	Asymmetrical – Hypotrophy on the right side
Sub-gluteal lines	Symmetrical

Posterior superior iliac spine	Symmetrical
Iliac crests	Symmetrical
Inferior scapular margins	Externally rotated bilaterally
Medial scapular margins	Abducted bilaterally
Scapula alata	Positive bilaterally
Shoulder position	Symmetrical

Table 2 - Anterior view

Sole weight baring	Symmetrical - medially
Transversal sole arch	Decreased bilaterally
Longitudinal sole arch	Decreased bilaterally
Calf – medial part	Hypotrophy – right side
Calf – lateral part	Hypotrophy – right side
Patella	Both face medially
Thigh contour	Hypotrophy – right side
Anterior superior iliac spine	Symmetrical
Umbilicus position	Normal
Abdominal muscles	Hypotrophy – right side
Pectoralis muscle	Hypertrophy – right side
Trapezius muscle	Hypertrophy – left side
Sternocleidomastoid muscle	Hypertrophy – right side
Head position	Middle line

Table 3. Side view

Ankle position	In slight flexion - both
Knee joint position	Hyper extended - left
Position of pelvis	Anterior tilt
Lumbar part of spine	Increased lordosis
Abdomen	Protrusion
Thoracic part of spine	Increased kyphosis
Cervical spine	Decreased lordosis
Shoulder position	Protructed bilaterally
Head posture	Protracted forward

Dynamic tests:

Trendelemburg test: Negative.

Romberg test grade 1, 2: Negative.

Romberg test grade 3: Positive with mild lateral deviations.

3.3.2 Gait evaluation

Patient does not use crutches or brace while providing gait evaluation. Gait pattern is altered. Pathological signs are present and described as following:

- Initial foot contact of landing right extremity is provided with knee not fully extended.

- Decreased activation of quadriceps and glutei muscles during this phase on operated leg – sign of decreased knee stability.
- Rebound phase starts with medial aspect of the feet – sign of flat feet.
- Rhythm is not harmonical – patient stays longer time on the non operated leg and is careful when contacting the operated one: Sign of antalgic walking.
- Coordination of lower with upper extremities is reduced.
- Trunk synkinesis with upper extremities is reduced.
- Right lower extremity – slight external rotation during gait.
- Pain in operated right knee.
- Maintenance of slightly kyphotic posture while walking.

3.3.3 Examination of basic moving patterns according to Janda (8)

Trunk curl up: positive
Pathological sign: Curling movement of the trunk is decreased, back remains straight and anterior tilt of pelvis is present. The movement is mostly performed with flexion of the hip joint which indicates weakness of the abdominal muscles.

Head flexion: negative

Shoulder abduction: positive on the left side
Pathological sign: The movement starts with the supraspinatus muscle but elevation of the left shoulder begins at 40 degrees. This early elevation shows the overload of the upper trapezius muscle.

Push up: positive

Pathological sign: During this test winging and rotation of the scapulas occurs (scapula alata).

Hip extension: positive

Pathological sign: The motion starts with the activation of hamstring muscles and erector spinae muscle with the activation of the gluteus maximus muscle being delayed.

Hip abduction: positive

Pathological sign: The hip abduction is not pure with slight hip flexion being present.

Conclusion of examination of basic moving patterns:

Shortening of the hip flexors and weakness of abdominal muscles during trunk curl up. Altered scapulohumeral coordination during shoulder abduction and coming back from push up. Inhibition of m. rhomboids, m. serratus anterior, m. trapezius middle and lower part during push up.

Slight hip flexion during the hip abduction test indicates a degree of instability at the pelvic region and that gluteus minimus, medius and tensor faschia latae do not act in coordination and as prime movers during hip abduction.

3.3.4 Anthropometric examination

Weight: 57 kgr.

Height: 160 cm.

Two scales weight bearing:

Left = 30 kgr.

Right = 27 kgr.

Table 4 - Lower extremities measurement

Measurement of:	**Right leg**	**Left leg**
Functional Length	81,5 cm	81,5 cm
Anatomical Length	74 cm	74 cm
Thigh length	41 cm	41 cm
Middle leg length	39 cm	39 cm
Foot length	22,5 cm	22,5 cm
Circumference of thigh – quadriceps	47 cm	49 cm
Circumference of thigh – Vastus mediallis	41 cm	44 cm
Circumference of knee	37 cm	37 cm
Circumference of calf	35 cm	39 cm
Circumference of ankle	23,5 cm	24 cm
Circumference of foot	22 cm	22 cm

Table 5 - Upper extremities measurement

Measurement of:	**Right arm**	**Left arm**
Whole upper extremity length	66,5 cm	66,5 cm
Humerus length	30,5 cm	30,5 cm
Forearm length	23,5 cm	23,5 cm
Hand length	16,5 cm	16,5 cm
Circumference of upper arm	27,5 cm	27,5 cm
Circumference of forearm	22 cm	22 cm

Table 6 - Distances of the spine

Measurement of:	Result	Normal values
Stibor's distance	7 cm	7-10 cm
Flesh de forestier's distance	0 cm	0 cm
Cepoj's distance	**6 cm**	3-4 cm
Otto's distance	5 cm	4,5 cm
Thomayer's distance	**+10 cm**	0 cm
Lateroflexion	20 cm	20-25 cm
Shober's distance	6 cm	4-6 cm

Table 7 - Other anthropometrical measurements

Circumference of the head (at the height of glabella)	51 cm
Circumference of thorax (at middle sternum level)	70 cm
Circumference of thorax during breathing (at xifoid process level)	79 cm during maximal inspiration, 72 cm during maximal expiration, 7 cm difference
Circumference of waist (umbilicus level)	69 cm
Circumference of hips (at trochanter major level)	94 cm

Conclusion of anthropometric examination:

The examination showed differences at the circumference of thighs and calves. This is because of the hypotrophy of the muscles on these areas which is typical after this type of operation.

Also, increased flexibility for cervical spine (Cepoj's distance) and hyper flexibility of the whole spine (Thomayer's distance).

3.3.5 Palpation examination

During palpation I tried to examine the quality of the muscles' tone and trophy as well as for trigger points of the lower extremities. No trigger points or pain where present after this examination. The results are on the following board:

Table 8 – Palpation examination

Examined muscle	**Right**	**Left**
Gastrocnemius	Hypotonic, hypotrophic	Hypertonic
Quadriceps	Hypotonic, hypotrophic	Hypertonic
Hamstrings	Hypotonic, hypotrophic	Hypertonic
Tensor faschiae latae	Normal tonus	Normal tonus
Iliopsoas	Hypertonic	Hypertonic
Hip adductors (Pectineus, gracilis, adductor magnus/longus/brevis)	Hypotonic, hypotrophic	Normal tonus
Gluteus minimus	Hypertonic	Normal tonus
Gluteus medius	Hypertonic	Normal tonus
Gluteus maximus	Hypotonic, hypotrophic	Hypertonic
Piriformis	Hypertonic	Normal tonus

Conclusion of palpation examination:

The examination showed hypotonicity and hypotrophy of many of the above examined muscles on the right leg as well as hypertonicity for iliopsoas. On the non operated leg, hypertonicity was found for gastrocnemius, quadriceps, hamstrings, iliopsoas and gluteus maximus, indicating that these muscles have been overloaded and have to carry more of the body's weight.

3.3.6 Scar examination

- Around the operated knee there is no oedema.
- The scar is good in mobility and color, has healed properly and no further treatment will be necessary during sessions. During her last therapies she had a number of therapies concerning soft tissue elasticity.
- Patient maintains good mobility of the soft tissue around knee with auto therapy as she has been instructed in early therapies.

3.3.7 Neurologic examination according to Janda (8)

During neurologic examination the patient's tendon reflexes as well as her sensory ability on the lower extremities were tested.

Table 9 - Reflexes examination

Reflex	**Right**	**Left**
Babinski's	Negative (normal)	Negative
Chaddock's	Negative	Negative
Oppenheim's	Negative	Negative
Achille's	2 (normal)	2
Patellar	2	2
Suprapatellar	2	2

Table 10 - Sensory examination

Examination of:	Right	Left
Pain with a pinprick	Normal	Normal
Light touch	Normal	Normal
Position sense of toes	Normal	Normal
Graphesthesia	Normal	Normal
Two point discrimination	Normal	Normal
Temperature (test with a metal ruler)	Normal	Normal

Conclusion of the examination:

The examination showed normal reflexes and sensory ability of the patient.

3.3.8 Joint Play Examination according to Lewit (7)

Pathological findings:

-Left/Right metatarsophalangeal and interphalangeal joints:

-While examining pain is provoked.

-Bilateral restrictions of all these joints in all directions (dorsal, plantar, lateral).

-Left/Right Lisfranc joints:

-Restrictions in dorsal, plantar and rotation directions.

-There is pain during examination.

-Left/Right talocrural joints:

- There are restrictions in dorsal direction on both sides.

-There is pain during examination.

-Right/Left tibiofemoral and tibiofibular joints:

-There are no restrictions or excessive movements.

-Left patella:

-Mobile in medial, lateral and cranial direction.

-Caudal direction provokes pain and is restricted.

-Right patella:

- Restrictions in all directions.
- No pain is provoked when examining.

Conclusion of the examination:

The examination showed restrictions and pain of the metatarsophalangeal and interphalangeal joints in all directions. Right and left Lisfranc joins are restricted in dorsal, plantar and rotation directions with pain presence. On the left and right talocrural joints there are also restrictions in dorsal directions and pain. Right patella is restricted in all directions and left one in caudal direction with pain presence.

3.3.9 Muscle Strength Examination according to Kendall (5)

The muscles' strength of the lower extremities where examined according to Kendall. The results are shown in the following board:

Table 11 – Muscle strength examination

Muscle group tested	**Right leg**	**Left leg**
Hip Abductors	4	5
Hip Adductors	4	5
Hip Flexors	4	5
Hip Extensors	4	5
Hip E/IRotators	4/4	5/5
Knee Flexors	4 – pain present	5
Knee Extensors	4	5
Ankle PFlexors	4+	5
Ankle DFlexors	5	5

Conclusion of the examination:

The examination showed weakness of the majority of the muscles on the operated leg. Also, pain was provoked while testing the right knee flexors and the patient graded it with number 3 according to the pain scale 0-10. On the non operated leg, the majority of the muscles were of normal strength apart from the hip abductors and adductors which scored under the normal strength grade.

3.3.10 Muscle Length Examination

The goniometry of the lower limbs' joints was provided in either supine lying position or prone lying position. In the following board it is described active and passive range of motion measurement of the joints.

Table 12 - Muscle Length Examination according to Janda (8)

	Right leg	**Left leg**
Quadriceps femoris	1	0
Hamstrings	1	1
Gastrocnemius	1	0
Soleus	0	0
Hip adductors	1	0
Hip abductors	1	0
Iliopsoas	1	1

Conclusion of the examination:

The examination showed moderate shortness of quadriceps, hamstrings, gastrocnemius, iliapsoas, hip adductors and adductors on the right leg. On the left side, only hamstrings and iliopsoas were found shortened.

3.3.11 Range of Motion Examination

Table 13 - ROM Examination - Goniometry

	Range of motion	**Range of motion**
Motion	**Right side (Active/Passive)**	**Left side (Ative/Passive)**
Ankle PF	35°/40°	45°/50°
Ankle DF	15°/20°	20°/25°
Knee F	120°/ 130°	135°/150°
Knee E	5°/0°	0°/0°
Hip IR	30°/40°	45°/55°
Hip ER	25°/30°	35°/45°
Hip ADD	10°/15°	15°/20°
Hip ABD	30°/35°	40°/45°
Hip F with knee F	100°/110°	110°/120°
Hip E	15°/20°	25°/30°

Conclusion of the examination:

There is limited range of motion for all the joints on the right side compared to the ones on the left. The ROM differences between right and left lower extremities are demonstrated clearly in the above table. The limited range of motion can happen due to muscle weakness, muscle shortness or restrictions in joint play.

3.3.12 Conclusion of Initial Kinesiologic Evaluation

Patient has a kyphotic/ lordotic posture while standing. After posture examination, the main points are flat feet disorder, hypotrophy on right calf, thigh and gluteal muscles. Proceeding cranially, when standing, ankles are in slightly flexed position and the left knee remains hyper extended. Pelvis is in anterior tilt, lumbar spine has increased lordosis and abdomen is protracted. Right abdominal side is slightly hyportrophic, thoracic part of the spine has increased lordosis and cervical has decreased lordosis. Right side pectoralis major, trapezius upper and sternocleidomastoid are slightly hypertrophic.

During dynamic tests, Romberg test grade 3 (closed eyes), was positive and patient would loose balance, indicating the low ability of proprioception. While walking, there is decreased activation of quadriceps and gluteal muscles on the right.

Synkinesis is altered for the lower extremities and trunk, with the upper extremities. Basic movement pattern tests were all pathological except from head flexion, indicating a series of muscle disbalances and inhibition. In description, there was shortening of the hip flexors and weakness of abdominal muscles during trunk curl up. Also, altered scapulohumeral coordination during shoulder abduction and coming back from push up. Inhibition of m. rhomboids, m. serratus anterior, m. trapezius middle and lower part during push up.

Slight hip flexion, during the hip abduction test, indicates a degree of instability at the pelvic region and that gluteus minimus, medius and tensor faschia latae do not act in coordination and as prime movers during hip abduction.

Through joint play examination, we could locate restrictions and pain of the metatarsophalangeal and interphalangeal joints in all directions. Right and left Lisfranc joins are restricted in dorsal, plantar and rotation directions with pain presence. On the left and right talocrural joints there are also restrictions in dorsal directions and pain. Right patella is restricted in all directions and left one in caudal direction with pain presence.

Additionally, muscle strength and length examinations showed weakness and shortness for many muscles on the right- operated extremity. The values can be seen in

the tables 11 and 12.

Joint ROM was also restricted on the operated side. Table 13 clearly shows the values of restriction compared to the non operated extremity.

3.4 Short term and Long term rehabilitation plan

Short term rehabilitation plan

- Eliminate pain feeling in the right knee joint while walking.
- Increase patient's knee stability.
- Restore ROM of the operated knee and other joints.
- Restore tonicity of the muscles in which it was altered.
- Increase muscle strength of the muscles which showed weakness during the strength examination.
- Release joint play restrictions.
- Improve proprioception and dynamic neuromotor strength in increasingly challenging sensorimotor training exercises.
- Optimize lower extremities' weight bearing.
- Improve endurance and performance during challenging exercises.

Long term rehabilitation plan

- Continue with muscle strength improvement.
- Improve dynamic balance and agility during challenging balance exercises with increased velocity and intensity.
- Enhance dynamic flexibility with demanding movement pattern exercises in increased speed and intensity (as high knee jogging, long backward jumps etc.).
- Decrease possibilities of new trauma of same origin.
- Return to favorite sport activities and restore as well as improve previous performance.

3.5 Therapy progress

1st Therapeutic Unit (03.01.2011).

- Initial Kinesiologic examination.

Subjective finding:

Patient feels fine today and ready for therapy.

Objective finding:

Patient has pain in her knee joint while walking. The therapy and exercises will be applied with care not to cause pain or damage.

Goal of the therapy:

- Improve joint play of the joints which have restrictions.
- Relax the muscles of the lower limbs and increase the ROM of the joints.
- Promote cardiovascular conditioning and muscle trophy with active exercises.
- Improve muscle strength, endurance and coordination.
- Improve proprioception of the lower extremities with special focus on the operated leg.

Procedure:

- Mobilization technique for the following joints:
    - IP joints – on both feet: Mobilization in dorsal, plantar and lateral directions.
    - MTP joints - on both feet: Mobilization in dorsal, plantar and lateral directions. Mobilization in rotation for the 1st MTP joint.
    - Lisfranc joint – right/ left foot: Mobilization in dorsal and plantar direction. Also rotation in tibial and fibular direction.
    - Talocrural joint – on both legs: Mobilization in dorsal direction
    - Left patella: Mobilization in caudal direction.

- Right patella: Mobilization in alll directions.

- Post Isometric Relaxation (PIR) technique to eliminate abnormal tonicity and improve loss of motion for the following muscles:
  - Gastrocnemius – both sides: Patient is in supine lying position with feet out of the bed. With one hand I stabilize the distal part of tibia. With my other hand I bring the foot into maximal dorsal flexion. The patient is asked to breathe in and keep her breath, resist my force for about 10 seconds, then breathe out and relax. Therapist follows the relaxation and patient relaxes for about 15 seconds. After the technique is repeated two more times.
  - Tibialis anterior – right side: Patient is in supine lying position with feet out of the bed. With one hand I stabilize the distal part of tibia. The patient is asked to breathe in, keep her breath and try to resist the force for about 10 seconds, then breathe out and relax. Therapist follows the relaxation and patient relaxes for about 15 seconds. The technique is repeated for two more times.
  - Hip adductors – both extremities: Patient is supine lying with her legs extended. One leg is brought in maximal abduction. Other hand fixates the pelvis. The technique is then provided as described previously.
  - Hip abductors – both extremities: Patient is side lying, holding the bed, with the inferior leg bent. Therapist is behind the patient, fixating the pelvis with one hand. Other hand supports the involved leg out of the bed, in adduction. The patient is asked to breathe in and keep her breath, hold her whole leg against gravity for 10 seconds, breath out and relax. Therapist follows the relaxation, patient relaxes for about 15 seconds and repeats the technique 3 times.
  - Hamstrings – both extremities: Patient is supine with her legs extended. One extended leg is brought passively into maximal hip flexion. Other

hand fixates opposite knee joint to prevent pelvic tilt. The patient is asked to breath in, resist with minimal force towards extension for 8-10 seconds, breathe out and relax. Therapist follows the relaxation, patient relaxes for about 15 seconds and repeats the technique 3 times.

- Gluteus maximus- both sides: Patient is supine line and the technique is repeated 3 times.
- Quadriceps – both extremities: Patient is in prone line with extended legs. One leg is brought in maximal knee flexion. Other hand stabilizes the pelvis. The same technique is then provided 3 times.
- Piriformis – both sides: Patient is prone with her knees flexed at 90° and hips in maximal internal rotation. Therapist's hands are on the medial aspect of each ankle. Patient is asked to breath in, resist with minimal force towards external rotation, breathe out and relax. Therapist follows the relaxation, patient relaxes for about 15 seconds and repeats the technique 3 times.
- Iliopsoas – both sides: Patient is standing at the edge of the table, grasps one bent knee joint and slowly lies on the bed. Other leg is hanging out of the bed. Therapist's hand fixates the pelvis. The other hand is on the distal part of femur. The technique is then provided 3 times.

- Isometric exercises using over ball:
  - Over ball under the heel – operated leg: The patient is in supine lying position, with both lower limbs extended on the bed. Placing a ball under one of the patient's heels, she is asked to press the ball towards the bed and keep the foot at the same place throughout the exercise, while the therapist continuously pushes the foot from side to side, trying to bring the patient's foot out of balance. The exercise activates many muscles, from the trunk down to the toes, and makes them work together improving in this way muscle balance and coordination (2 sets x 10 repetitions).
  - Over ball under the knee: Supine on the bed, with lower limbs extended, a ball is placed under the knee. Patient provides isometric contraction of

quadriceps while therapist tries to bring the leg out of balance by pushing. The exercise activates hip adductors and abductors as well as hamstrings, improving muscle balance and coordination (2x10 times).

- PNF technique to strengthen vastus mediallis:
    - Pattern 1st diagonal to flexion, technique slow reversal - hold (3 times).

- Sensomotoric training to improve muscle balance and proprioception:
    - Correction of initial posture.
    - **Initially, preparatory facilitation was applied in the following way:**
    - Stroking of feet soles – 1 min. on each foot.
    - Walking on rough surface for 30 seconds.
    - Manual vibratory oscillation on the SI joints for 30 seconds.
    - Manual vibratory oscillation on the sub occipital extensors.
    - With manual vibration of the above areas, the patient becomes aware of these areas and high mechanoreceptor areas are stimulated.
    - **Progress of sensomotoric training:**
    - Formation of the short foot to improve its biomechanical position:
        - Patient is sitting with flexed knees at about 80°.
        - Therapist passively shortens the foot approximating the metatarsal heads towards the heel and waits for some seconds so as the patient will perceive the movement (each foot x 3 times).
        - Next, patient is asked to assist with the movement and the procedure is repeated for 3 times.
        - Then, patient provides actively the procedure with a sheet of paper under her sole and she tries to grasp the paper (3 times). Patient's position is also altered from sitting to standing – weight bearing position so as she will become increasingly aware of her foot's function (3 repetitions).

- Leg toe raises: Patient has normal feet base and elevates herself using her calf muscles (10 times).
- Single leg balance with ball passes: Patient balances herself on one semi flexed extremity for 10 seconds and accepts ball passes (10 sec. x 3 times on each leg). Patient can perform the exercises with minimal stability difficulty and no pain. The level of difficulty will be increased.
- Single leg balance on Bosu balance board: Patient balances herself on one semi flexed extremity for 10 seconds. To increase patient's effort, therapist pushes her slightly in different directions while she tries to maintain balance (10 sec. x 3 times on each leg).

- Active exercise using tools:
  - Stationary bike: 5 minutes cycling against light resistance with normal speed. Height is adjusted properly for full knee extension. The exercise trains the lower extremities' muscles, strengthens them and improves the knee's function ability on the operated leg.

2nd Therapeutic Unit (05.01.2011).

Subjective finding:

Patient states that after last therapy, she feels more relaxed on the muscles of the lower extremities. Mild pain in her operated knee still exists while walking. Today she feels fine and ready for therapy.

Objective finding:

Last therapy showed positive results on the effort to relax the hypertonic muscles. Her walking pattern has small improvement and she is slightly more free in motion. We will continue our therapy and the sensomotoric program will be more challenging.

Goal of the therapy:

- Improve joint play of the joints on which restrictions remain.
- Relax the muscles of the lower limbs and increase the ROM of the joints.
- Promote cardiovascular conditioning and muscle trophy with active exercises.
- Improve muscle strength, endurance and coordination.
- Continue with proprioception improvement of the lower extremities with special focus on the operated leg.

Procedure:

- After examination, joint play restrictions were still present and mobilization technique was applied in the following joints:
    - MTP joints - on both feet: Mobilization in dorsal, plantar and lateral directions. Mobilization in rotation for the 1st MTP joint.
    - Lisfranc joint – right/left foot: Mobilization in dorsal and plantar direction. Also rotation in tibial and fibular direction.
    - Talocrural joint – on both legs: Mobilization in dorsal direction
    - Left patella: Mobilization in caudal direction.
    - Right patella: Mobilization in all directions.

- Post Isometric Relaxation (PIR) technique for the following muscles (technique applied as described in last session):
    - Gastrocnemius – both sides.
    - Tibialis anterior – right side.
    - Hip adductors – both extremities.
    - Hip abductors – both extremities.
    - Hamstrings – both extremities
    - Quadriceps – both extremities
    - Piriformis – both sides.
    - Iliopsoas – both sides.

- Active exercises to maintain as well as increase ROM:
    - Prone knee flexion: Initially patient is advised to provide the exercise slowly and not to cause any pain in her knee. While in prone position, patient actively flexes her knee joint to the end point. She holds for 15 seconds, then relaxes and repeats the exercise (3 times).
    - Prone knee extension: Patient's right - operated lower leg hangs out of bed. Other leg applies force on the heel of the involved leg. She holds for 20 seconds, then relaxes and repeats the exercise.
    - Supine knee extension: A soft ball is placed under the patient's heel. She is asked to press her knee downwards and hold it for 15 seconds, then relax and repeat the exercise (3 times).

- Active abdominal exercises (also in diagonals) to improve body core stability (3 sets x 10 repetitions).

- Active exercises to increase functional strength:
    - Squats: Patient is standing with shoulder width base. Her toes point forward. Then slowly she lowers her hips. The knees are aligned over the first and second toes (5 times).
    - Back steps using a step board - both legs starting with the non-operated on the board: Patient is standing on a step board. She extends the operated leg and slowly lowers her body until the involved leg taps the floor behind her. She repeats the exercise trying to increase the extension each time. With increasing the extension, the exercise becomes more challenging (5 times).
    - Stationary lunges: Patient steps forward the non operated leg at ¾ of her full stride as starting position. Most of her body weight is on the forward leg. Then lowers her body until the forward leg is almost parallel to the floor. Knee should remain aligned with the 1st and 2nd toe. Operated leg also bends at the knee joint (5 repetitions x each leg).

- PNF technique to strengthen vastus mediallis:
    - Pattern 1st diagonal to flexion, technique slow reversal - hold (3 times).

- Sensomotoric training to improve muscle balance and proprioception:
    - Correction of initial posture.
    - **Initially, preparatory facilitation was applied in the following way:**
    - Stroking of feet soles – 1 min. on each foot.
    - Walking on rough surface for 30 seconds.
    - Manual vibratory oscillation on the SI joints for 30 seconds.
    - Manual vibratory oscillation on the sub occipital extensors.
    - With manual vibration of the above areas, the patient becomes aware of these areas and high mechanoreceptor areas are stimulated.
    - **Progress of sensomotoric training:**
    - Formation of the short foot to improve its biomechanical position:
        - Patient is sitting with flexed knees at about 80°.
        - Therapist passively shortens the foot approximating the metatarsal heads towards the heel and patient is asked to assist with the movement. Therapist waits for some seconds so as the patient will perceive the movement (each foot x 5 times).
        - Then, patient provides actively the procedure with a sheet of paper under her sole and she tries to grasp the paper (5 times). Patient's position is also altered from sitting to standing – weight bearing position so as she will become increasingly aware of her foot's function (3 repetitions).
    - Leg toe raises: Patient has normal feet base and elevates herself using her calf muscles (10 times).
    - Single leg balance with ball passes: Patient balances herself on one semi flexed extremity for 10 seconds and accepts ball passes (10 sec. x 3 times on each leg). Patient can perform the exercises with minimal stability difficulty and no pain. The level of difficulty will be increased.

- Single leg balance on Bosu balance board: Patient balances herself on one semi flexed extremity for 10 seconds. To increase patient's effort, therapist pushes her slightly in different directions while she tries to maintain balance (10 sec. x 3 times on each leg).
- Two leg balance on Bosu balance board with closed eyes. To increase patient's effort, therapist pushes her slightly in different directions while she tries to maintain balance (10 sec. x 3 times).
- One leg balance on Bosu with closed eyes: During this exercise, patient starts loosing control of balance and the exercise is interrupted. For this reason, therapist places his both hands stable beside her pelvis to help her control her body balance. Patient becomes impressing fast aware of her body position and performs well the quality of the exercise until the third attempt (4 repetitions).
- **Sensomotoric training and muscle strengthening using Theraband for the operated leg – standing position:**
- Hip abductions: Theraband is fixated around right ankle and a stable beam, passing behind left ankle. Patient does not hold herself in order to become aware of the change of the center of gravity. Then, slowly performs repeated hip abductions (2 sets x 10 times).
- Hip adductions: Theraband fixated around the ankle and the beam. Then, slowly performs repeated hip adductions (2 sets x 10 times).
- Hip flexions: Theraband fixation remains the same. Patient performs slowly hip flexions (2 sets x 10 times).
- Hip extensions: Theraband fixation remains the same. Patient performs slowly hip extensions (2 sets x 10 times).

- Active exercise using tools:
  - Stationary bike: 5 minutes cycling against light resistance with normal speed. Height is adjusted properly for knee extension (no pain). The exercise trains the lower extremities' muscles, strengthens them and improves the knee's function ability of the operated leg.

3rd Therapeutic Unit (07.01.2011).

Subjective finding:

Patient feels good today and says that yesterday, one day after last therapy, she felt pain in her knee only a couple of times during evening time while walking. Today she felt pain again while walking to her work but it was for shorter time that usually.

Objective finding:

Therapy progresses without any complications and with positive results on ROM and strength for the lower extremities. We will continue therapy as planned.

Goal of the therapy:

- Improve joint play of the joints on which restrictions remain.
- Relax the muscles of the lower limbs and increase the ROM of the joints.
- Promote cardiovascular conditioning and muscle trophy with active exercises.
- Improve muscle strength, endurance and coordination.
- Continue with proprioception improvement of the lower extremities with special focus on the operated leg.

Procedure:

- After examination, joint play restrictions **but** with **no provoked pain** were still present and mobilization technique was applied in the following joints:
    - MTP joints - on both feet: Mobilization in dorsal, plantar and lateral directions. Mobilization in rotation for the 1st MTP joint.
    - Lisfranc joint – right/left foot: Mobilization in dorsal and plantar direction. Also rotation in tibial and fibular direction.
    - Talocrural joint – on both legs: Mobilization in dorsal direction
    - Left patella: Mobilization in caudal direction.
    - Right patella: Mobilization in all directions.

- Post Isometric Relaxation (PIR) technique for the following muscles (technique applied as described in the 1st session):
    - Gastrocnemius – both sides.
    - Tibialis anterior – right side.
    - Hip adductors – both extremities.
    - Hip abductors – both extremities.
    - Hamstrings – both extremities
    - Quadriceps – both extremities
    - Piriformis – both sides.
    - Iliopsoas – both sides.

- Active exercises to maintain as well as increase ROM:
    - Prone knee flexion: Initially patient is advised to provide the exercise slowly and not to cause any pain in her knee. While in prone position, patient actively flexes her knee joint to the end point. She holds for 15 seconds, then relaxes and repeats the exercise (3 times).
    - Prone knee extension: Patient's right - operated lower leg hangs out of bed. Other leg applies force on the heel of the involved leg. She holds for 20 seconds, then relaxes and repeats the exercise.
    - Supine knee extension: A soft ball is placed under the patient's heel. She is asked to press her knee downwards and hold it for 15 seconds, then relax and repeat the exercise (3 times).

- Active abdominal exercises (also in diagonals) to improve body core stability (3 sets x 10 repetitions).

- Active exercises to increase functional strength:
    - Squats: Patient is standing with shoulder width base. Her toes point forward. Then slowly she lowers her hips. The knees are aligned over the

first and second toes (5 times).

- Back steps using a step board - both legs starting with the non operated on the board: Patient is standing on a step board. She extends the operated leg and slowly lowers her body until the involved leg taps the floor behind her. She repeats the exercise trying to increase the extension each time. With increasing the extension, the exercise becomes more challenging (5 times).
- Stationary lunges: Patient steps forward the non operated leg at ¾ of her full stride as starting position. Most of her body weight is on the forward leg. Then lowers her body until the forward leg is almost parallel to the floor. Knee should remain aligned with the 1st and 2nd toe. Operated leg also bends at the knee joint (5 repetitions x each leg).

- PNF technique to strengthen vastus mediallis:
  - Pattern 1st diagonal to flexion, technique slow reversal - hold (3 times).

- Sensomotoric training to improve muscle balance and proprioception:
  - **Initially, preparatory facilitation was applied in the following way:**
  - Stroking of feet soles – 1 min. on each foot.
  - Walking on rough surface for 30 seconds.
  - Manual vibratory oscillation on the SI joints for 30 seconds.
  - Manual vibratory oscillation on the sub occipital extensors to increase awareness.
  - **Progress of sensomotoric training:**
  - Formation of the short foot to improve its biomechanical position:
    - Patient is sitting with flexed knees at about 80°.
    - Therapist passively shortens the foot approximating the metatarsal heads towards the heel and patient is asked to assist with the movement. Therapist waits for some seconds so as the patient will perceive the movement (each foot x 5 times).

- Then, patient provides actively the procedure with a sheet of paper under her sole and she tries to grasp the paper (5 times). Patient's position is also altered from sitting to standing – weight bearing position so as she will become increasingly aware of her foot's function (3 repetitions).

- Leg toe raises: Patient has normal feet base and elevates herself using her calf muscles (10 times).
- Single leg balance with ball passes: Patient balances herself on one semi flexed extremity for 10 seconds and accepts ball passes (10 sec. x 3 times on each leg). Patient can perform the exercises with minimal stability difficulty and no pain. The level of difficulty will be increased.
- Single leg balance on Bosu balance board: Patient balances herself on one semi flexed extremity for 10 seconds. To increase patient's effort, therapist pushes her slightly in different directions while she tries to maintain balance (10 sec. x 3 times on each leg).
- Two leg balance on Bosu balance board with closed eyes. To increase patient's effort, therapist pushes her slightly in different directions while she tries to maintain balance (10 sec. x 3 times).
- One leg balance on Bosu with closed eyes: During this exercise, patient starts loosing control of balance and the exercise is interrupted. For this reason, therapist places his both hands stable beside her pelvis to help her control her body balance. Patient becomes impressing fast aware of her body position and performs well the quality of the exercise until the third attempt (4 repetitions).
- **Sensomotoric training and muscle strengthening using Theraband for the operated leg – standing position:**
- Hip abductions: Theraband is fixated around right ankle and a stable beam, passing behind left ankle. Patient does not hold herself in order to become aware of the change of the center of gravity. Then, slowly performs repeated hip abductions (2 sets x 10 times).
- Hip adductions: Theraband fixated around the ankle and the beam. Then,

slowly performs repeated hip adductions (2 sets x 10 times).

- Hip flexions: Theraband fixation remains the same. Patient performs slowly hip flexions (2 sets x 10 times).
- Hip extensions: Theraband fixation remains the same. Patient performs slowly hip extensions (2 sets x 10 times).

- Active exercises using tools:
  - Stairmaster for 15 repetitions x 3 sets.
  - Stationary bike: 5 minutes cycling against light resistance with normal speed.

4th Therapeutic Unit (10.01.2011).

Subjective finding:

Patient feels good today and she didn't feel any pain while going to her work in the morning. Yesterday, during noon time, she had pain for longer periods than usually in her knee but she thinks she overused it. Also, she feels changes on her leg muscles and that she can control better her steps. She says that she feels more stable.

Objective finding:

Patient shows improved stability and coordination while walking and changing direction. The sensomotoric program has already shown positive results and with aspection we can see that the muscles of the operated leg are more active than the start of therapy, unloading the work of the contra lateral leg. After measurement, vasti muscles' circumference is increased 0,5cm. (41,5 cm) and 2 scales weight bearing is improved: Right 28 kgr. Left:29kgr.

Goal of the therapy:

- Improve joint play of the joints on which restrictions remain.
- Relax the muscles of the lower limbs and increase the ROM of the joints.

- Promote cardiovascular conditioning and muscle trophy with active exercises.
- Improve muscle strength, endurance and coordination.
- Continue with proprioception improvement of the lower extremities with special focus on the operated leg.

Procedure:

- After examination, joint play restrictions were still present and mobilization technique was applied in the following joints:
    - Lisfranc joint – right/left foot: Mobilization in dorsal and plantar direction.
    - Talocrural joint – on both legs: Mobilization in dorsal direction
    - Right patella: Mobilization in caudal, medial and lateral directions.

- Post Isometric Relaxation (PIR) technique for the following muscles (technique applied as described in the 1st session):
    - Gastrocnemius – both sides.
    - Tibialis anterior – right side.
    - Hip adductors – both extremities.
    - Hip abductors – both extremities.
    - Hamstrings – both extremities
    - Quadriceps – both extremities
    - Piriformis – both sides.
    - Iliopsoas – both sides.

- Active exercises to maintain as well as increase ROM:
    - Prone knee flexion: Initially patient is advised to provide the exercise slowly and not to cause any pain in her knee. While in prone position, patient actively flexes her knee joint to the end point. She holds for 15 seconds, then relaxes and repeats the exercise (3 times).
    - Prone knee extension: Patient's right - operated lower leg hangs out of bed. Other leg applies force on the heel of the involved leg. She holds for

20 seconds, then relaxes and repeats the exercise.

- Supine knee extension: A soft ball is placed under the patient's heel. She is asked to press her knee downwards and hold it for 15 seconds, then relax and repeat the exercise (3 times).

- Active abdominal exercises (also in diagonals) to improve body core stability (3 sets x 10 repetitions).

- Active exercises to increase functional strength:
  - Squats: Patient is standing with shoulder width base. Her toes point forward. Then slowly she lowers her hips. The knees are aligned over the first and second toes (5 times).
  - Squats with knee lifts: Patient, after squatting, shifts her body weight to one leg (non-operated first) and holds for 5-10 seconds (3 times x each leg).
  - Squats and reaches: Patient squats and shifts her body weight on one leg. Other leg provides lateral reach until the hip fully extends (5 repetitions x each leg).
  - Squats with alternating reaches: Provided as the previous exercise but alternating legs after each repetition. The speed of alternation is increased gradually (2 x 15 repetitions).
  - Back steps using a step board - both legs starting with the non-operated on the board: Patient is standing on a step board. She extends the operated leg and slowly lowers her body until the involved leg taps the floor behind her. She repeats the exercise trying to increase the extension each time. With increasing the extension, the exercise becomes more challenging (5 times).
  - Stationary lunges: Patient steps forward the non operated leg at ¾ of her full stride as starting position. Most of her body weight is on the forward leg. Then lowers her body until the forward leg is almost parallel to the floor. Knee should remain aligned with the 1st and 2nd toe. Operated leg

also bends at the knee joint (5 repetitions x each leg).

- Sideways lunges: Staring position is standing with feet together. Patient steps one leg laterally into a lunge and returns to starting position (12 repetitions x each leg).
- Reverse lunges: Starting position is standing with feet together. Patient steps backwards into a lunge and returns to standing (10 repetitions x each leg)

- PNF technique to strengthen vastus mediallis:
  - Pattern 1st diagonal to flexion, technique slow reversal - hold (3 times).

- Sensomotoric training to improve muscle balance and proprioception:
  - **Initially, preparatory facilitation was applied in the following way:**
  - Stroking of feet soles – 1 min. on each foot.
  - Walking on rough surface for 30 seconds.
  - Manual vibratory oscillation on the SI joints for 30 seconds.
  - Manual vibratory oscillation on the sub occipital extensors.
  - **Progress of sensomotoric training:**
  - Formation of the short foot to improve its biomechanical position:
    - Patient is sitting with flexed knees at about 80°.
    - Therapist passively shortens the foot approximating the metatarsal heads towards the heel and patient is asked to assist with the movement. Therapist waits for some seconds so as the patient will perceive the movement (each foot x 5 times).
    - Then, patient provides actively the procedure with a sheet of paper under her sole and she tries to grasp the paper (5 times). Patient's position is also altered from sitting to standing – weight bearing position so as she will become increasingly aware of her foot's function (3 repetitions).
  - Leg toe raises.
  - Single leg balance with ball passes.

- Single leg balance on Bosu balance board.
- Two leg balance on Bosu balance board with closed eyes. (10 sec. x 3 times).
- One leg balance on Bosu with closed eyes: Patient today demonstrates good performance during this exercise. She can maintain her balance thought the exercise and therapist is not necessary to assist her in this.
- Squats on **Posturomed** platform: This exercise is more challenging for the patient. Also, squats on one leg standing are performed (4 repetitions each time).
- **Sensomotoric training using wobble and tool:**
    - Exercises are performed in different directions for anterior, diagonal and posterior weight shifting (20 seconds x each direction).
    - Then, exercise is repeated by the patient with closed eyes to increase her concentration and control. Therapist controls the quality of the exercise and patient's balance.
- **Sensomotoric training using rocker board tool:** Same exercises as wobble but with this tool exercises are more challenging.
- **Sensomotoric training and muscle strengthening using Theraband for the operated leg – standing position:**
- Hip abductions: Theraband is fixated around right ankle and a stable beam, passing behind left ankle. Patient does not hold herself in order to become aware of the change of the center of gravity. Then, slowly performs repeated hip abductions (2 sets x 10 times).
- Hip adductions: Theraband fixated around the ankle and the beam. Then, slowly performs repeated hip adductions (2 sets x 10 times).
- Hip flexions: Theraband fixation remains the same. Patient performs slowly hip flexions (2 sets x 10 times).
- Hip extensions: Theraband fixation remains the same. Patient performs slowly hip extensions (2 sets x 10 times).
- **Sensomotoric training against external resistance to improve**

functional strength and muscle coordination:

- Lunges with Theraband: A band is fixated around patient's trunk to cause resistance. Patient performs lunges controlling her body weight shifting (10 repetiotions x each leg).
- Squats with Theraband: Band's fixation remains the same. Patient performs squats concentrating in muscle coordination and weight shifting.

- **Active exercises using tools:**
  - Stairmaster for 15 repetitions x 3 sets.
  - Stationary bike: 5 minutes cycling against light resistance with normal speed. Height is adjusted properly for knee extension (no pain). The exercise trains the lower extremities' muscles, strengthens them and improves the knee's function ability on the operated leg.

5th Therapeutic Unit (12.01.2011).

Subjective finding:

Patient states that since last therapy, she hasn't felt any pain in her knee and she is happy to see that she can control her body during different activities with less effort than before therapeutic sessions.

Objective finding:

Joint play restrictions have been released and patient can walk free of these restrictions. Muscle tone has been restored for the hypertonic muscles but not totally. There are no complications.

Goal of the therapy:

- Relax the muscles of the lower limbs and increase the ROM of the joints.

- Promote cardiovascular conditioning and muscle trophy with active exercises.
- Improve muscle strength, endurance and coordination.
- Continue with proprioception improvement of the lower extremities with special focus on the operated leg.

Procedure:

- Post Isometric Relaxation (PIR) technique for the following muscles (technique applied as described in the 1st session):
    - Gastrocnemius – both sides.
    - Tibialis anterior – right side.
    - Hip adductors – both extremities.
    - Hip abductors – both extremities.
    - Hamstrings – both extremities
    - Quadriceps – both extremities
    - Piriformis – both sides.
    - Iliopsoas – both sides.

- Active exercises to maintain as well as increase ROM:
    - Prone knee flexion: Initially patient is advised to provide the exercise slowly and not to cause any pain in her knee. While in prone position, patient actively flexes her knee joint to the end point. She holds for 15 seconds, then relaxes and repeats the exercise (3 times).
    - Prone knee extension: Patient's right - operated lower leg hangs out of bed. Other leg applies force on the heel of the involved leg. She holds for 20 seconds, then relaxes and repeats the exercise.
    - Supine knee extension: A soft ball is placed under the patient's heel. She is asked to press her knee downwards and hold it for 15 seconds, then relax and repeat the exercise (3 times).

- Active abdominal exercises (also in diagonals) to improve body core stability (3 sets x 10 repetitions).

- Active exercises to increase functional strength:
    - Squats: Patient is standing with shoulder width base. Her toes point forward. Then slowly she lowers her hips. The knees are aligned over the first and second toes (5 times).
    - Squats with knee lifts: Patient, after squatting, shifts her body weight to one leg (non-operated first) and holds for 5-10 seconds (3 times x each leg).
    - Squats and reaches: Patient squats and shifts her body weight on one leg. Other leg provides lateral reach until the hip fully extends (5 repetitions x each leg).
    - Squats with alternating reaches: Provided as the previous exercise but alternating legs after each repetition. The speed of alternation is increased gradually (2 x 15 repetitions).
    - Back steps using a step board - both legs starting with the non-operated on the board: Patient is standing on a step board. She extends the operated leg and slowly lowers her body until the involved leg taps the floor behind her. She repeats the exercise trying to increase the extension each time. With increasing the extension, the exercise becomes more challenging (5 times).
    - Stationary lunges: Patient steps forward the non operated leg at ¾ of her full stride as starting position. Most of her body weight is on the forward leg. Then lowers her body until the forward leg is almost parallel to the floor. Knee should remain aligned with the 1^{st} and 2^{nd} toe. Operated leg also bends at the knee joint (5 repetitions x each leg).
    - Sideways lunges: Staring position is standing with feet together. Patient steps one leg laterally into a lunge and returns to starting position (12 repetitions x each leg).

- Reverse lunges: Starting position is standing with feet together. Patient steps backwards into a lunge and returns to standing (10 repetitions x each leg).

- PNF technique to strengthen vastus mediallis:
  - Pattern 1st diagonal to flexion, technique slow reversal - hold (3 times).

- Sensomotoric training to improve muscle balance and proprioception:
  - **Preparatory facilitation as described in last therapy.**
  - **Progress of sensorimotor training:**
  - Formation of the short foot to improve its biomechanical position:
    - Patient is sitting with flexed knees at about 80°.
    - Patient provides actively the procedure with a sheet of paper under her sole and she tries to grasp the paper (10 times). Patient's position is also altered from sitting to standing – weight bearing position so as she will become increasingly aware of her foot's function (10 repetitions).
  - Leg toe raises: Patient has normal feet base and elevates herself using her calf muscles (10 times).
  - Single leg balance with ball passes: Patient balances herself on one semi flexed extremity for 10 seconds and accepts ball passes (10 sec. x 3 times on each leg). Patient can perform the exercises with minimal stability difficulty and no pain. The level of difficulty will be increased.
  - Single leg balance on Bosu balance board: Patient balances herself on one semi flexed extremity for 10 seconds. To increase patient's effort, therapist pushes her slightly in different directions while she tries to maintain balance (10 sec. x 3 times on each leg).
  - Two leg balance on Bosu balance board with closed eyes. To increase patient's effort, therapist pushes her slightly in different directions while

she tries to maintain balance (10 sec. x 3 times).

- One leg balance on Bosu with closed eyes: During this exercise, patient starts loosing control of balance and the exercise is interrupted. For this reason, therapist places his both hands stable beside her pelvis to help her control her body balance. Patient becomes impressing fast aware of her body position and performs well the quality of the exercise until the third attempt (4 repetitions).
- **Sensomotoric training using wobble tool:**
    - Exercises are performed in different directions for anterior, diagonal and posterior weight shifting (20 seconds x each direction).
- Then, exercise is repeated by the patient with closed eyes to increase her concentration and control. Therapist controls the quality of the exercise and patient's balane.
- **Sensomotoric training using rocker tool:** Same exercises as wobble but with this tool exercises are more challenging.
- Squats on **Posturomed** platform: This exercise is more challenging for the patient. Also, squats on one leg standing are performed and also with closed eyes. Patient performs the exercise with **good quality** and **concentration** (4 repetitions each time).
- **Sensomotoric training and muscle strengthening using Theraband for the operated leg – standing position:**
- Hip abductions: Theraband is fixated around right ankle and a stable beam, passing behind left ankle. Patient does not hold herself in order to become aware of the change of the center of gravity. Then, slowly performs repeated hip abductions (2 sets x 10 times).
- Hip adductions: Theraband fixated around the ankle and the beam. Then, slowly performs repeated hip adductions (2 sets x 10 times).
- Hip flexions: Theraband fixation remains the same. Patient performs slowly hip flexions (2 sets x 10 times).
- Hip extensions: Theraband fixation remains the same. Patient performs

slowly hip extensions (2 sets x 10 times).

- **Sensomotoric training against external resistance to improve functional strength and muscle coordination:**
- Lunges with Theraband: A band is fixated around patient's trunk to cause resistance. Patient performs lunges controlling her body weight shifting (10 repetiotions x each leg).
- Squats with Theraband: Band's fixation remains the same. Patient performs squats concentrating in muscle coordination and weight shifting.

- **Active exercises using tools:**
  - Stairmaster for 15 repetitions x 3 sets.
  - Stationary bike: 5 minutes cycling against moderate resistance with normal speed. Height is adjusted properly for knee extension (no pain). The exercise trains the lower extremities' muscles, strengthens them and improves the knee's function ability on the operated leg.

6th Therapeutic Unit (14.01.2011).

1st session:

Subjective patient's feeling:

Patient feels fine today and says that almost no pain was present since our last session in her knee. She says that she feels her muscles strong and coordinated while walking and has no difficulties with it. Also, she can maintain demanding body positioning while working with minor effort and says that her fatigue while working of in different activities has reduced significantly.

Objective patient's feeling:

Patient is in good state with no complications after the therapies. The changes of improvement after all the therapies will be noted after the Final Kinesiologic Examination will take place in the 2nd session today.

Goal of the therapy:

- Relax the muscles of the lower limbs and increase the ROM of the joints.
- Promote cardiovascular conditioning and muscle trophy with active exercises.
- Improve muscle strength, endurance and coordination.
- Continue with proprioception improvement of the lower extremities with special focus on the operated leg.

Procedure:

- Post Isometric Relaxation (PIR) technique for the following muscles (technique applied as described in the 1st session):
    - Gastrocnemius – both sides.
    - Tibialis anterior – right side.
    - Hip adductors – both extremities.
    - Hip abductors – both extremities.
    - Hamstrings – both extremities
    - Quadriceps – both extremities
    - Piriformis – both sides.
    - Iliopsoas – both sides.

- Active exercises to maintain as well as increase ROM:
    - Prone knee flexion: Initially patient is advised to provide the exercise slowly and not to cause any pain in her knee. While in prone position, patient actively flexes her knee joint to the end point. She holds for 15 seconds, then relaxes and repeats the exercise (3 times).
    - Prone knee extension: Patient's right - operated lower leg hangs out of bed. Other leg applies force on the heel of the involved leg. She holds for 20 seconds, then relaxes and repeats the exercise.
    - Supine knee extension: A soft ball is placed under the patient's heel. She is asked to press her knee downwards and hold it for 15 seconds, then relax and repeat the exercise (3 times).

- Active abdominal exercises (also in diagonals) to improve body core stability (3 sets x 10 repetitions).

- Active exercises to increase functional strength:
    - Squats (5 times).
    - Squats with knee lifts (3 times x each leg).
    - Squats with reaches
    - Squats with alternating reaches: Provided as the previous exercise but alternating legs after each repetition. The speed of alternation is increased gradually (2 x 15 repetitions).
    - Back steps using a step board - both legs starting with the non-operated on the board.
    - Stationary lunges (5 repetitions x each leg).
    - Sideways lunges: Staring position is standing with feet together. Patient steps one leg laterally into a lunge and returns to starting position (12 repetitions x each leg).
    - Reverse lunges: Starting position is standing with feet together. Patient steps backwards into a lunge and returns to standing (10 repetitions x each leg)

- PNF technique to strengthen vastus mediallis:
    - Pattern 1st diagonal to flexion, technique slow reversal - hold (3 times).

- Sensomotoric training to improve muscle balance and proprioception:
    - **Preparatory facilitation as described in last therapy.**
    - **Progress of sensomotoric training:**
    - Formation of the short foot to improve its biomechanical position:
        - Patient is sitting with flexed knees at about 80°.
        - Patient provides actively the procedure with a sheet of paper under her sole and she tries to grasp the paper (10 times). Patient's

position is also altered from sitting to standing – weight bearing position so as she will become increasingly aware of her foot's function (10 repetitions).

- Leg toe raises: Patient has normal feet base and elevates herself using her calf muscles (10 times).
- Single leg balance with ball passes: Patient balances herself on one semi flexed extremity for 10 seconds and accepts ball passes (10 sec. x 3 times on each leg). Patient can perform the exercises with minimal stability difficulty and no pain. The level of difficulty will be increased.
- Single leg balance on Bosu balance board: Patient balances herself on one semi flexed extremity for 10 seconds. To increase patient's effort, therapist pushes her slightly in different directions while she tries to maintain balance (10 sec. x 3 times on each leg).
- Two leg balance on Bosu balance board with closed eyes. To increase patient's effort, therapist pushes her slightly in different directions while she tries to maintain balance (10 sec. x 3 times).
- One leg balance on Bosu with closed eyes: During this exercise, patient starts loosing control of balance and the exercise is interrupted. For this reason, therapist places his both hands stable beside her pelvis to help her control her body balance. Patient becomes impressing fast aware of her body position and performs well the quality of the exercise until the third attempt (4 repetitions).
- **Sensomotoric training using wobble tool:**
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- Then, exercise is repeated by the patient with closed eyes to increase her concentration and control. Therapist controls the quality of the exercise and patient's balance.
- **Sensomotoric training using rocker and tool:** Same exercises as wobble but with this tool exercises are more challenging.

- Squats on **Posturomed** platform: This exercise is more challenging for the patient. Also, squats on one leg standing are performed and also with closed eyes. Patient performs the exercise with good quality and concentrationl (4 repetitions each time).

- **Sensomotoric training and muscle strengthening using Theraband for the operated leg – standing position:**
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- **Sensomotoric training against external resistance to improve functional strength and muscle coordination:**
- Lunges with Theraband: A band is fixated around patient's trunk to cause resistance. Patient performs lunges controlling her body weight shifting (10 repetiotions x each leg).
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- **Active exercises using tools:**
  - Stairmaster for 15 repetitions x 3 sets.
  - Stationary bike: 5 minutes cycling against moderate resistance with normal speed. Height is adjusted properly for knee extension (no pain). The exercise trains the lower extremities' muscles, strengthens them and improves the knee's function ability on the operated leg.

2nd session:

3.6 Final Kinesiologic Evaluation (14.01.2011)

3.6.1 Postural examination

Table 14 - Posterior view

Heel form and position	Symmetrical
Achille's tendon contour	**Symmetrical**
Achille's tendon shape	Both face laterally, co
Calves	**Improved symmetry – still hypotrophic right**
Popliteal lines	Same level
Thigh contour	**Almost Symmetrical** -Mild hypotrophy on right side
Sub-gluteal lines	Symmetrical
Posterior superior iliac spine	Symmetrical
Gluteal muscles	**Almost Symmetrical** -Mild hypotrophy on right side
Iliac crests	Symmetrical
Inferior scapular margins	**Imrpoved but still external rotation bilaterally**
Medial scapular margins	**Still abducted bilaterally**
Scapula alata	**Improved** but still positive bilaterally
Shoulder position	Symmetrical

Table 15 - Anterior view

Sole weight baring	Symmetrical
Transversal sole arch	**Improved** but still decreased bilaterally
Longitudinal sole arch	**Improved** but still decreased bilaterally
Calf – medial part	**Improved – almost symmetrical**
Calf – lateral part	**Improved – still asymmetrical**
Patella	**Improved** - both face **anteriorly** now
Thigh contour	**Almost Symmetrical -**Mild hypotrophy on right side
Anterior superior iliac spine	Symmetrical
Umbilicus position	Normal (midline)
Abdominal muscles	**Symmetrical -** no hypotrophy on right side
Pectoralis muscle	Still hypertrophic – right side
Trapezius muscle	Still hypertrophic – left side
Sternocleidomastoid muscle	Still hypertrophic – right side
Head position	Middle line

Table 16 - Side view

Knee joint position	**Normal**
Position of pelvis	Normal
Lumbar part of spine	**Improved** but still with increased lordosis
Thoracic part of spine	**Improved** but still with increased kyfosis
Cervical part of spine	**Improved** but still with decreased lordosis
Shoulder position	**Improved** but still with slight protraction bilaterally

Conclusion:

Improved changes in different segmented areas as noted and highlighted in the tables.

Dynamic tests:

Trendelemburg test: Negative

Romberg test grade 3: Negative

3.6.2Gait evaluation

Patient walks fluently and with good rhythm and stability. Also:

- Initial arm synkinesis restriction has reduced but is still present.
- Normal right knee extension is present in mid-phase.
- No external rotation of right extremity.
- Maintenance of proper upright posture while walking.

Patient does not use crutches or brace while providing gait evaluation. Gait pattern is altered. Pathological signs are present and described as following:

- Initial foot contact of landing right extremity is provided **now** with right knee **fully** extended (initially it was not fully extended).
- Activation of quadriceps and glutei muscles during this phase on operated leg is **normal** (initially it was decreased) – it means knee stability improved.
- Flat feet disorder is improved, longitudinal and transverse arches increased. Rebound phase starts with centro-lateral aspect of the soles - improved base of support.
- Rhythm is harmonical, steps are more confident – patient now stays equal time on each leg while walking. Previous sign of antalgic walking is now eliminated.

- Coordination of lower with upper extremities is normal (initially it was decreased).
- Trunk synkinesis with upper extremities is normal (initially was decreased).
- Right lower extremity – neutral position while walking and **no** external rotation during gait as initially.
- No pain in operated right knee anymore.
- Maintenance of generally better upright posture while walking.

3.6.3 Evaluation of Basic Movement Patterns according to Janda (8)

Trunk curl up: **negative.**
Head flexion: negative.
Shoulder abduction: positive on the left side **but improved.**
Pathological sign: The movement starts with the supraspinatus muscle but elevation of the left shoulder begins at 40 degrees. This early elevation shows the overload of the upper trapezius muscle.
Push up: positive **but improved.**
Pathological sign: During this test winging and rotation of the scapulas occurs. (scapula alata).
Hip extension: **negative.**
Hip abduction: **negative**.

Conclusion of examination of basic moving patterns

Improvement changes for:

- Trunk curl up: **negative.**

- Hip extension: **negative.**
- Hip abduction: **negative**.

Pathological signs remained for:

Shoulder abduction: positive on the left side **but improved.**

Push up: positive **but improved.**

Conclusion:

After examination, we can see that the pathological signs of basic movement patterns, which concern the lower half of the body, do not exist any more. This shows the improvement of muscle coordination after the therapeutic approach.

Pathological signs which have remained show that further therapy is required for these areas. However, these signs have improved and the muscle incoordination does not appear as early as before therapy sessions when providing the tests. The improvement is described with delayed but altered scapulohumeral coordination during shoulder abduction and coming back from push up and delayed but still inhibition of m. rhomboids, m. serratus anterior, m. trapezius middle and lower part during push up. Future therapies are necessary and would help with the elimination of these pathological signs.

3.6.4 Anthropometric examination

Weight: 57 kgr.

Height: 160 cm.

Table 17 - Two scales weight bearing:

Present	Past
Left = 28,5 kgr.	Left = 30 kgr.
Right = 28,5 kgr.	Right = 27 kgr.

Conclusion:

Improvement of weight bearing with ideal body weight distribution. Patient unconsciously distributes equal weight on her soles and this reflects the positive results of the sensorimotor training program and the restoration of muscle disbalances.

Table 18 - Lower extremities measurement:

	Present	**Present**	**Past**	**Past**	**Improvement**
Measurement of:	**Right leg**	**Left leg**	**Right leg**	**Left leg**	
Functional Length	- (same)	-	81,5 cm	81,5 cm	-
Anatomical Length	-	-	74 cm	74 cm	-
Thigh length	-	-	41 cm	41 cm	-
Middle leg length	-	-	39 cm	39 cm	-
Foot length	-	-	22,5 cm	22,5 cm	-
Circumference of thigh – quadriceps	**48 cm**	**49,5**	47 cm	49 cm	**R: +1cm L: + 0.5 cm**
Circumference of thigh – Vastus mediallis	**42,5 cm**	**44,5 cm**	41 cm	44 cm	**R: +1,5 cm L: +0,5 cm**

Circumference of knee	-	-	37 cm	37 cm	-
Circumference of calf	**38 cm**	**39,5 cm**	36 cm	39 cm	**R: +2 cm** **L: +0,5 cm**
Circumference of ankle	**24 cm**	24 cm	23,5 cm	24 cm	-
Circumference of foot	-	-	22 cm	22 cm	-

Conclusion:

Circumference increase for thighs, calves and right ankle shows that the muscle trophy around these areas has been partially or totally restored.

Table 19 - Upper extremities measurement:

	Present	**Present**	**Past**	**Past**
Measurement of:	**Right arm**	**Left arm**	**Right arm**	**Left arm**
Whole upper extremity length	- (same)	-	66,5 cm	66,5 cm
Humerus length	-	-	30,5 cm	30,5 cm
Forearm length	-	-	23,5 cm	23,5 cm
Hand length	-	-	16,5 cm	16,5 cm
Circumference of upper arm	27,5 cm	27,5 cm	27,5 cm	27,5 cm
Circumference of forearm	22 cm	22 cm	22 cm	22 cm

Conclusion:

No changes of the anthropometric data for the upper extremities.

Table 20 - Distances of the spine:

	Finally	**Initially**	**Normal values**	**Result**
Stibor's distance	7 cm	7 cm	7-10 cm	Normal
Flesh de forestier's distance	Normal	Normal	0 cm	Normal
Cepoj's distance	**6 cm**	**6 cm**	**3-4 cm**	**Hyperflexibility**
Otto's distance	5 cm	5 cm	4,5 cm	Normal
Thomayer's distance	**+10 cm**	**+10 cm**	**0 cm**	**Hyperflexibility**
Shober's distance	6 cm	6 cm	20-25 cm	Normal
			4-6 cm	

Conclusion:

No changes for the distances of the spine. Hyperflexibility is noted for the whole spine with Thomayer's distance being 10 cm greater than normal.

Table 21 - Other anthropometrical measurements:

	Finally	**Initially**	**Difference**
Circumference of the head (at the height of glabella)	Same	51 cm	-
Circumference of thorax (at middle sternum level)	Same	70 cm	-
Circumference of thorax during breathing (at xifoid process level)	Same	79 cm during maximal inspiration, 72 cm during maximal expiration, 7 cm difference	-

Circumference of waist (umbilicus level)	68 cm	69 cm	**-1cm**
Circumference of hips (at trochanter major level)	92,5 cm	94 cm	**-1,5 cm**

Conclusion of anthropometric examination:

Circumference of waist decreased 1 cm and of hips 1, 5 cm.

3.6.5 Palpation examination

Table 22 – Palpation examination

	Finally	**Finally**	**Initially**	**Initially**
Examined muscle	**Right**	**Left**	**Right**	**Left**
Gastrocnemius	*Normal tonus, slight hypotrophy*	*Normal*	Hypotonic, hypotrophic	Hypertonic
Quadriceps	*Normal tonus, slight hypotrophy*	*Normal*	Hypotonic, hypotrophic	Hypertonic
Hamstrings	*Normal tonus, slight hypotrophy*	*Normal*	Hypotonic, hypotrophic	Hypertonic
Tensor faschiae latae	Normal	Normal	Normal tonus	Normal tonus
Iliopsoas	*Normal*	Normal	Hypertonic	Hypertonicity
Hip adductors (Pectineus, gracilis, adductor magnus/longus/brevis)	*Normal tonus, slight hypotrophy*	Normal	Hypotonic and hypotrophic	Normal tonus
Gluteus minimus	*Normal*	Normal	Hypertonic	Normal tonus
Gluteus medius	*Normal*	Normal	Hypertonic	Normal tonus
Gluteus maximus	*Normal tonus, slight hypotrophy*	*Normal*	Hypotonic, hypotrophic	Hypertonic
Piriformis	*Normal*	Normal	Hypertonic	Normal tonus

Conclusion:

All the muscles with initial pathological signs have been restored in tonicity. Also, their trophy has improved and this reflects the efficiency of the therapeutic program.

3.6.6 Neurological examination according to Janda (8)

Table 23 - Reflexes examination

Reflex	**Right**	**Left**
Babinski's	Negative (normal)	Negative
Chaddock's	Negative	Negative
Oppenheim's	Negative	Negative
Achille's	2 (normal)	2
Patellar	2	2
Suprapatellar	2	2

Table 24 - Sensory examination:

Examination of:	**Right**	**Left**
Pain with a pinprick	Normal	Normal
Light touch	Normal	Normal
Position sense of toes	Normal	Normal
Graphesthesia	Normal	Normal
Two point discrimination	Normal	Normal
Temperature (test with a metal ruler)	Normal	Normal

Conclusion:

The neurological examination showed same normal reflexes and sensory ability of the patient as in the Initial Kisesiologic Examination.

3.6.7 Joint Play Examination according to Karel Lewit (7)

-Left/Right metatarsophalangeal and interphalangeal joints:

-No restrictions or pain when examined.

-Left Lisfranc joint:

-No restrictions.

-Right Lisfranc joint:

-No restrictions.

-Left/Right talocrural joints:

- No restrictions.

-Left patella:

-No restrictions.

-Right patella:

-No restrictions.

Conclusion:

For all the joints with pathological signs during the Initial Kinesiologic Evaluation, joint play movements have been restored and the restrictions in ROM have been restored.

3.6.8 Muscle Strength Examination according to Kendall (5)

The muscles' strength of the lower extremities where examined according to Kendall. The results are shown in the following board:

Table 25 – Muscle strength examination

	Finally	**Finally**	**Initially**	**Initially**
Muscle group tested	**Right leg**	**Left leg**	**Right leg**	**Left leg**
Hip Abductors	5-	5	4	5
Hip Adductors	5-	5	4	5
Hip Flexors	5-	5	4	5
Hip Extensors	5-	5	4	5
Hip E/IRotators	5-/5-	5/5	4/4	5/5
Knee Flexors	5 , no pain	5	4 , pain	5
Knee Extensors	4+	5	4	5
Ankle PFlexors	5	5	4+	5
Ankle DFlexors	5	5	5	5

Conclusion of the examination:

Muscle strength has improved for all the muscles of the lower extremities. As demonstrated in the above table, on the operated leg only minor muscle weakness is still present with the most significant for knee extensors (4+).

3.6.9 Muscle Length Examination according to Vladimir Janda (8)

Table 26 – Musle length examination

	Finally	**Finally**	**Initially**	**Initially**
	Right leg	**Left leg**	**Right leg**	**Left leg**
Quadriceps femoris	0	0	1	0
Hamstrings	0	0	1	1
Gastrocnemius	0	0	1	0
Soleus	0	0	0	0

Hip adductors	0	0	1	0
Hip abductors	0	0	1	0
Iliopsoas	0	0	1	1

Conclusion:

No shortness is present for the muscles of the lower extremities. Restrictions in ROM caused by muscle shortness have been restored.

3.6.10 Range of Motion Examination - Goniometry

The goniometry of the lower limbs' joints was provided in either supine lying position or prone lying position. In the following board it is described active and passive range of motion measurement of the joints.

Table 27 – ROM Examination

	Finally	**Finally**	**Initially**	**Initially**
Motion	**Right side (Active/Passive)**	**Left side (Ative/Passive)**	**Right side (Active/Passive)**	**Left side (Ative/Passive)**
Ankle PF	45°/50°	45/50	35°/40°	45°/50°
Ankle DF	20°/25°	20°/25°	15°/20°	20°/25°
Knee F	135°/140°	135°/150°	120°/ 130°	135°/150°
Knee E	0°/0°	0°0°	5°/0°	0°/0°
Hip IR	40°45°	45°/55°	30°/40°	45°/55°
Hip ER	35°/45°	35°/45°	25°/30°	35°/45°
Hip ADD	20°/25°	20°/25°	10°/15°	15°/20°
Hip ABD	40°/45°	40°/45°	30°/35°	40°/45°
Hip F with knee F	110°/120°	110°/120°	100°/110°	110°/120°
Hip E	25°/30°	25°/30°	15°/20°	25°/30°

Conclusion of the examination:

ROM has been increased or restored for all joints of the operated leg. The above table shows clearly the scores during initial and final examination.

3.7 Evaluation of the effect of the Therapy, prognosis

After 6 therapeutic units, the progress of the patient in therapeutic point of view is remarkable. The therapeutic procedures which were used did not cause any compilations during the therapy period and resulted in gradual improvement of the patient's state. Joint play mobilization released totally joint restrictions, PIR technique eliminated abnormal muscle tone and restrored physiological ROM. Additionally, PNF strengthening technique contributed a lot in strengthening vastus mediallis and isometric and isotonic exercises produced positive results in increasing muscle strength and coordination. However, the sensorimotor (SMT) training program offered precious and combined positive results for the patient in terms of balance, coordination, strength, endurance and more. Briefly, the positive effects of the overall therapy are described as following:

- **Gait** pattern and **posture improved**. The initial pathological signs while walking were eliminated and the patient **maintained** a **better upright posture**.
- **Pain** in the knee joint while walking **disappeared** until the end of therapies.
- **Body weight distribution** unconsciously changed to **equal** when measuring on 2 scales.
- **Joint play restrictions** for MTP, IP, Lisfrank, talocrural joints and patellas **disappeared**.
- Muscle **length** and **tonicity** on the lower extremities was **restored**.
- Muscle **strength** on the right – operated extremity also **improved** with most muscles scoring grade 5 when examining according to Kendall.

- ROM increased on the operated extremity.
- Patient's **sensory motor ability**, a very important part for a patient after ACL reconstruction, also **improved** and the results were significant. Patient developed her awareness of whole body positioning and was able to maintain center of gravity during challenging exercises. She could even perform exercises on unstable boards on one leg and with closed eyes – exercises in which initially balance could not be maintained.
- **Basic movement patterns** of trunk curl up, hip abduction and hip extension, which demonstrated pathological signs initially, **were restored** reflecting the improvement of **muscle coordination**.
- Muscle **trophy** also **increased** for all the initially hypotrophic muscles and the **anthropometric differences** in the involved areas **decreased**.
- The following tables support the above changes which can be described in numbers:

Table 28 – Anthropometric changes

		Finally	**Finally**	Initially	Initially
	Improvement	Right	Left	Right	Left
Circumference of thigh – quadriceps	R: +1cm L: + 0.5 cm	**48 cm**	**49,5**	47 cm	49 cm
Circumference of thigh – Vastus mediallis	R: +1,5 cm L: +0,5 cm	**42,5 cm**	**44,5 cm**	41 cm	44 cm
Circumference of calf	R: +2 cm L: +0,5 cm	**38 cm**	**39,5 cm**	36 cm	39 cm

Table 29 – Musle length changes

	Finally	**Finally**	**Initially**	**Initially**
	Right leg	**Left leg**	**Right leg**	**Left leg**
Quadriceps femoris	0 (no shortness)	0	1	0
Hamstrings	0	0	1	1
Gastrocnemius	0	0	1	0
Soleus	0	0	0	0
Hip adductors	0	0	1	0
Hip abductors	0	0	1	0
Iliopsoas	0	0	1	1

Table 30 – ROM changes

	Finally	**Initially**	***Finally***	***Initially***
	Right side (Active /Passive)	**Right side (Active /Passive)**	***Left side (Active /Passive)***	***Left side (Active/Passive)***
Ankle PF	**45°/50°**	35°/40°	*45/50*	*45°/50°*
Ankle DF	**20°/25°**	15°/20°	*20°/25°*	*20°/25°*
Knee F	**135°/140°**	120°/ 130°	*135°/150°*	*135°/150°*
Knee E	0°/0°	0°/0°	*0°0°*	*0°/0°*
Hip IR	**40°45°**	30°/40°	*45°/55°*	*45°/55°*
Hip ER	**35°/45°**	25°/30°	*35°/45°*	*35°/45°*
Hip ADD	**20°/25°**	10°/15°	***20°/25°***	***15°/20°***
Hip ABD	**40°/45°**	30°/35°	*40°/45°*	*40°/45°*

Hip F with knee F	**110°/120°**	100°/110°	*110°/120°*	*110°/120°*
Hip E	**25°/30°**	15°/20°	*25°/30°*	*25°/30°*

3.7.1 Prognosis

The prognosis for the patient is positive. She is in the phase of restoring dynamic neuromotoror strength, coordination and endurance after ACL reconstruction and the goals during this phase have been met. There were no complications during the therapy of this phase and the patient demonstrated a relatively quick and gradual improvement.

The next phase of rehabilitation, which she should follow, is to introduce her to more demanding activities and exercises. This phase can be described also as the athletic enhancement phase. She will be introduced to exercises as jogging, jumping forward or backward, high knee walking and generally a more challenging program for balance, agility, flexibility and strength combined with sensorimotor tarining.

In my point of view, the patient will be able to complete the next phase of rehabilitation successfully. When she will achieve this, the ACL Reconstructed knee joint will be even more stable and the risk of reappearance of a new damage due to external forces will be very low.

4 Conclusion

During the 2 – week rehabilitation at Central Military Hospital Prague (UVN) of a patient after ACL reconstruction, I was surprised to see the positive changes of the patient's initial condition. Here, I have to note that the patient initially was at a very good state in terms of strength and basic proprioception. Specifically, I was able to watch the patient becoming fast and steadily more skillful and coordinated when performing challenging exercises. Her balance and proprioceptive ability increased after every therapy and until the end of the overall therapy, balance could be maintained unconsciously even during various balance exercises on unstable boards with closed eyes. Also, I saw in practice that the used techniques of examination and therapy, can lead to a successful completion of a therapeutic program with the particular disorder. However, I should remark that an important role for the overall positive results played the kind of patient, who was a woman with a familiar scientific background (doctor of medicine). She demonstrated excellent cooperation and concentration during therapy and contributed a lot with its positive progress.

5 List of literature

List of books

1. Becker, J. M., & Stucchi, A. F. (2006). Essentials of surgery. Philadelphia: Elsevier/Saunders. ISBN: 0721681867

2. Drake, R. L., Vogl, W., Mitchell, A. W., & Gray, H. (2005). Gray's anatomy for students. Philadelphia: Elsevier/Churchill Livingstone. ISBN: 0443067023

3. Ellenbecker, T. S. (2000). Knee ligament rehabilitation. New York: Churchill Livingstone. ISBN: 0443075344

4. Kapandji, I. A.. The physiology of the joints. 6th ed., English ed. Edinburgh: Churchill Livingstone, 2007. Print.. ISBN: 070203942X

5. Kendall, F. P. (2005). Muscles, testing and function with posture and pain (5th ed.). Baltimore, MD: Lippincott Williams & Wilkins. ISBN: 0781747805

6. Lephart, S. M., & Fu, F. H. (2000). Proprioception and neuromuscular control in joint stability. Champaign, IL: Human Kinetics. ISBN: 0880118644

7. Lewit, K. (1999). Manipulative therapy in rehabilitation of the locomotor system (3rd ed.). Oxford: Butterworth-Heinemann. ISBN: 9780702030567

8. Liebenson, C. (2007). Rehabilitation of the spine: a practitioner's manual (2nd ed.). Philadelphia: Lippincott Williams & Wilkins. ISBN-10: 9780781729970

9. Magee, D. J. (2011). Athletic and sport issues in musculoskeletal rehabilitation. St. Louis, Mo.: Elsevier/Saunders. ISBN-10: 1416022643

10. Malek, M. M. (2001). Knee surgery: complications, pitfalls, and salvage. New York: Springer. ISBN-10: 9780387982946

11. Moore, K. L., & Dalley, A. F. (1999). Clinically oriented anatomy (4th ed.). Philadelphia: Lippincott Williams & Wilkins. ISBN: 0781736390

12. Noyes, F. R., & Westin, S. D. (2010). Knee disorders surgery, rehabilitation, clinical outcomes. Philadelphia, PA: Saunders/Elsevier. ISBN: 9781416054740

13. Page, P., Frank, C. C., & Lardner, R. (2010). Assessment and treatment of muscle imbalance: the Janda approach. Champaign, IL: Human Kinetics. ISBN: 0736074007

14. Platzer, W., & Spitzer, G. (2004). Color atlas and textbook of human anatomy (5th rev. and enlarged [English] ed.). Stuttgart: Georg Thieme Verlag;. ISBN: 3135333043

15. Wilk, K. E. (1997). Anterior cruciate ligament injuries. Champaign, IL: Human Kinetics.

List of electronic sources

16. Anterior cruciate ligament (ACL) surgery. (2011). WebMD - Better information. Better health. Retrieved April 11, 2011, from http://www.webmd.com/a-to-z-guides/anterior-cruciate-ligament-acl-surgery

17. Arthroscopic ACL surgery reconstruction. (2011). The center for orthopaedics and sports medicine. Retrieved April 12, 2011, from http://www.arthroscopy.com/sp05018.htm

18. Biomechanics of ACL - Wheeless' Textbook of Orthopaedics. (2011). Welcome to Wheeless' Textbook of Orthopaedics - Wheeless' Textbook of Orthopaedics. Retrieved April 12, 2011, from http://www.wheelessonline.com/ortho/biomechanics_of_acl

19. Bone and knee tissue graft for ACL surgery. (2011). WebMD - Better information. Better health. Retrieved April 11, 2011, from http://www.webmd.com/hw-popup/bone-and-knee-tissue-graft-for-acl-surgery

20. Hastreiter, D., M.D.., & ph.d.. (2011). UW MSK resident projects: ACL reconstruction. UW MSK radiology web lab. Retrieved April 11, 2011, from http://uwmsk.org/residentprojects/aclreconstruction.html

21. Mechanism of ACL Tear - Wheeless' Textbook of Orthopaedics. (2011). Welcome to Wheeless' Textbook of Orthopaedics - Wheeless' Textbook of Orthopaedics. Retrieved April 12, 2011, from http://www.wheelessonline.com/ortho/mechanism_of_acl_tear

22. Medscape: Medscape Access. (2011). Retrieved April 12, 2011, from http://emedicine.medscape.com/article/89442-treatment

23. Orthopedic Assessment Methods: Knee. (2011). Orthopedic Assessment Methods. Retrieved April 11, 2011, from http://orthoassessment.blogspot.com/search/label/Knee

24. Orthopedic Sports Medicine Corner: Guidelines for the 1st Week after ACL Reconstruction — The Nicholas Institute of Sports Medicine and Athletic Trauma (2011). Welcome to the Nicholas Institute of Sports Medicine and Athletic Trauma — The Nicholas Institute of Sports Medicine and Athletic Trauma. Retrieved April 11, 2011, from http://www.nismat.org/orthocor/acl_postop

25. Q-angle: Information from Answers.com. (2011). Answers.com: Wiki Q&A combined with free online dictionary, thesaurus, and encyclopedias. Retrieved April 11, 2011, from http://www.answers.com/topic/q-angle

26. The knee joint | medchrome. (2011). medchrome - online medical magazine. retrieved April 11, 2011, from http://medchrome.com/basic-science/the-knee-joint/

6 Supplement

6.1 List of Pictures

1. Picture 1 - Anatomy of the knee joint, frontal view: p.6 (2011) Anterior Cruciate Ligament Injuries - Page Your Orthopaedic Connection - AAOS. (2011). AAOS – Your Orthopaedic Connection. Retrieved April 10, 2011, from http://orthoinfo.aaos.org/topic.cfm?topic=A00549

2. Picture 2 – Ligaments of the knee: p.8 (2011) Page The knee joint | Medchrome - online medical magazine. Retrieved April 11, 2011, from http://medchrome.com/basic-science/the-knee-joint/

3. Picture 3 – menisci of the knee: p.10 - Images. (2011). Dictionary Images. Retrieved April 11, 2011 from http://images.yourdictionary.com/meniscus

4. Picture 4 - Knee tendons: p.11 (2011) Retrieved April 11, 2011, from http://factotem.org/library/database/Knee-Articles/Knee-anatomy-physiology.shtml

5. Picture 5 – Knee muscles: p.12 (2011) from http://www.mountain-bike-cumbria.co.uk/articles.php?id=kneeinjuries

6. Picture 6 - Torn ACL : p.17 (2011) The Athletic Advisor. Retrieved April 12, 2011, from http://www.athleticadvisor.com/Injuries/LE/Knee/torn_acl.htm

7. Picture 7 – Knee arthroscopy : p. 18 (2011) from http://www.mendmyknee.com/_img/arthroscopic-acl-tear-surgery.gif

8. Picture 8 – Lachman's test: p.19 (2011) Retrieved April 11, 2011, from http://www.sportsdoc.umn.edu/Clinical_Folder/Knee_Folder/Knee_Exam/lachmans.htm

9. Picture 9 – Anterior drawer test: p.20 (2011) Retrieved April 11, 2011,from http://www.sportsdoc.umn.edu/Clinical_Folder/Knee_Folder/Knee_Exam/anterior%20drawer.htm

10. Picture 10 – Pivot shift test: p. 21(2011) Retrieved April 11, 2011,from http://www.snowclub.gr/forums/lofiversion/index.php/t4923.html

11. Picture 11 – The Q angle: p. 24 (2011) Retrieved April 11, 2011,from http://www.leadingmd.com/virtual/education/assets/q_angle.gif

12. Picture 12 – ACL Surgery: p.28 (2011) Bone and knee tissue graft for ACL surgery. WebMD - Better information. Better health. Retrieved April 11, 2011, from http://www.webmd.com/hw-popup/bone-and-knee-tissue-graft-for-acl-surgery

6.2 List of Tables

6.3 List of Abbreviations

ABD : Abduction
ACL : Anterior Cruciate Ligament
ADD : Adduction
DF : Dorsal Flexion
E : Extension
F : Flexion
IP : Inter Phalangeal
IR : Internal Rotation
MTP : Meta Tarso Phalangeal
PF : Plantar Flexion
ROM : Range Of Movement
SMT : Sensori Motor Training

6.4 Model Informed Consent

INFORMOVANÝ SOUHLAS

V souladu se Zákonem o péči o zdraví lidu (§ 23 odst. 2 zákona č.20/1966 Sb.) a Úmluvou o lidských právech a biomedicíně č. 96/2001, Vás žádám o souhlas k vyšetření a následné terapii. Dále Vás žádám o souhlas k nahlížení do Vaší dokumentace osobou získávající způsobilost k výkonu zdravotnického povolání v rámci praktické výuky a s uveřejněním výsledků terapie v rámci bakalářské práce na FTVS UK. Osobní data v této studii nebudou uvedena.

Dnešního dne jsem byla odborným pracovníkem poučena o plánovaném vyšetření a následné terapii. Prohlašuji a svým dále uvedeným vlastnoručním podpisem potvrzuji, že odborný pracovník, který mi poskytl poučení, mi osobně vysvětlil vše, co je obsahem tohoto písemného informovaného souhlasu, a měla jsem možnost klást mu otázky, na které mi řádně odpověděl.
Prohlašuji, že jsem shora uvedenému poučení plně porozuměla a výslovně souhlasím s provedením vyšetření a následnou terapií.
Souhlasím s nahlížením níže jmenované osoby do mé dokumentace a s uveřejněním výsledků terapie v rámci studie.

Datum:…….

Osoba, která provedla poučení:……..

Podpis osoby, která provedla poučení:……..

Vlastnoruční podpis pacienta /tky:……...

6.4 Ethic Committee