CHARLES UNIVERSITY
Faculty of Physical Education and Sport
Department of Physiotherapy

PHYSIOTHERAPEUTIC APPROACH ON CHONDROMALACIA PATELLAE

Bachelor Thesis

April 2008, Prague

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Application for
Opinion of UK FTVS Ethic Committee

On the project of Bachelor Thesis including human participants

Title: Case report

Project form: Bachelor Thesis

Author: (crucial author) Nikolaos Karydis

Supervisor (in case of student project) Kateřina Maršáková

Project description M 224

The case report of rehabilitation the patient with anamnesis .....elaborated with the vocational sight of physiotherapist in UVN PRAHA (Health care unit)

No one invasive procedure will be applied.

Proposal of Agreement (enclosed)

Prague 21/1/08 Author's signature .....

Statement
UK FTVS Ethic Committee

Committee members: Ass. Prof. Staša Bartůňková, M.D., CSc.
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The project was authorized by Ethic Committee UK FTVS with reference number: 0016/2008

Date: 5. 2. 2008

Ethic Committee UK FTVS evaluated submitted project and found no discrepancy to valid principles, instructions and international guidelines for biomedical research, including human participants.

Author of project fulfilled necessary conditions for the agreement of Ethic Committee.

Faculty stamp

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Abstract

Title: Physiotherapeutic approach on chondromalacia patellae.

Author: Nikolaos Karydis

Aim: In this bachelor thesis will be discussed the problematic of physiotherapeutic approach on treatment of chondromalacia patellae as well as the results elaborated after 5 physical therapy sessions with a patient representing most of chondromalacia patellae symptomatology.

Methods: The methods used included reeducation and strengthening exercises for quadriceps and gluteus medius muscles, soft tissue and joint mobilization techniques by Lewit, sensory motor stimulation as well as magnetotherapy. Post isometric relaxation (PIR) together with post facilitating stretch (PFS) techniques were also used.

Results: Remarkable improvements were noted on pain decrease, feet pronation and longitudinal arch formation, as well as weight bearing. Fair improvements were noted on soft tissue mobility and muscle length.

Key words: Patellofemoral joint syndrome, Q angle, patellar tracking, vastus medialis, articular cartilage, joint stress, force distribution.

Declaration

I declare that this Bachelor Thesis has been based entirely on my own individual work and on my own practice that took place at Ústředni Vojenská Nemocnice in Prague, from 21/01/08-1/02/08. All the information used for the elaboration of this Bachelor Thesis has been taken from the list of literature recorded in the end of this Thesis.

In Prague,
April 2008

Nikolaos Karydis

Acknowledgement

I am grateful to my family for supporting me throughout my whole life and helping me make my dreams come true. I would also like to thank my companion Joanna, for her understanding and solidarity during my three year study in physiotherapy.

Appreciating the opportunity they gave me, special thanks to Mr. Konstantinos Diamantopoulos and Mr. Ernest Nacho for their help and guidance during my clinical work placement at Physiopraxis rehabilitation center. The knowledge I gained from my first experience in a professional environment is more than valuable.

Finally I would like to thank Mgr Kateřina Maršáková for her co-operation, patience and time during the supervision of this Bachelor Thesis, as well as all my professors during my three year study in Charles University for their superb teaching and priceless knowledge they gave me.

Preface

As a former athlete during my child and pubertal years, I had many times encountered injuries personally or among other co-athletes. My further experience with different kinds of sports as a physical education and sport student, made me realize even more the importance of injury prevention. Injuries though may not only happen during athletic activities but also during activities of daily living. At this point should be stressed the importance of proper treatment and physiotherapeutic intervention in the patient's rehabilitation once an injury has occurred, with even most important being the diminution of same injury re-occurrence. For this reason, proper physiotherapeutic approach should not only aim at the treatment of the injury itself but also at the elimination of contributing to the injury factors.

This Thesis is a review in bibliography, publications and researches concerning the problematic of conservative approach in treatment of chondromalacia patellae, followed by a case study of a patient representing most of chondromalacia patellae symptomatology. In the following chapters will be discussed the mechanisms of injury, subjective and objective examination as well as rehabilitation techniques for the management of chondromalacia patellae.

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General part

1. Overview of the lower extremity

The lower extremity supports body weight and gives the ability to move from one place to the other (locomotion). The lower limb has six major parts:

- The gluteal region, bordered superiorly by the iliac crest, medially by the intergluteal cleft and posteriorly by the gluteal fold. It is a transitional region between the trunk and the free (mobile) lower limb. It includes the buttocks (the posterior region of the lower limb) and the hip region (the lateral region).
- The femoral region, which consists by the femoral bone and lies between the gluteal region proximally and the knee region distally.
- The knee region, which includes the distal femoral condyles, the patella, the proximal tibial condyles, the head of fibula, as well as the joints formed by these bony structures.
- The leg region, which contains the tibia and the fibula. It is this part of the lower extremity that lies between the knee and the ankle joint (medial/lateral malleoli).
- The talocrural region (ankle), which includes the distal part of the leg and the malleoli, as well as the talocrural joint.
- The foot region, which is the distal part of the lower extremity. It contains the tarsus, metatarsus and the phalanges. [26]

2. Anatomy of the knee joint

2.1 Articulations of the knee joint

The knee joint is the larger and most superficial joint and it is considered to be a modified ginglymus or hinge type joint. It consists of three articulations in one and these are:

- The tibiofemoral articulations (lateral and medial), formed by the articulation of femoral condyles with the condyles of tibia.

- The patellofemoral articulation, formed by the patella articulating with the patellar surface of the femur.

The fibula is not involved in the knee joint. [10] [26] [18]

2.2 The joint capsule of the knee joint

The knee joint capsule consists externally by a thin fibrous membrane (the fibrous capsule) and internally by the synovial membrane which lines all internal surfaces that are not covered by articular cartilage and contain synovial fluid.

The fibrous layer attaches superiorly proximal to the articular margins of the femoral condyles and inferiorly to the margins of the tibial plateau (superior tibial articular surface). Medially and laterally it is continuous with the margins of quadriceps tendon, patella and patellar ligament.

The synovial membrane attaches to the periphery of the articular cartilage that covers the femoral and tibial condyles, the posterior surface of the patella and the margins of the menisci. From the posterior side of the joint, the synovial membrane continues anteriorly where it covers the cruciate ligaments and the infrapatellar fat pad, so they are excluded from the articular cavity. [26] [10]

The expansions from the vasti and the fascia lata together with the iliotibial band (ITB) constitute the medial and lateral patellar retinacula.

Posteriorly, the capsule consists of vertical fibers arising from the femoral condyles and the intercondular fossa of the femur, therefore situated at the sides and in front of the cruciate ligaments (Figures 1.1, 1.2). [10] [26]

2.3 Stability of the knee joint

The knee is a mechanically weak joint due to the incongruence of its articular surfaces. Therefore the stability of the knee depends on the strength and tendons of the surounding muscles together with the ligaments connecting femur and tibia. The most important muscle involved in the stability of the knee is the quadriceps femoris, especially the fibers of vastus medialis and vastus lateralis. The importance of this muscle is so great that, the knee could function surprisingly well after a ligamental strain, if quadriceps femoris is well trained. [26]

The extended position of the knee, when the foot is on the ground, is the most stable position of the joint. In this position, the articular surfaces are most stabilised and the collateral and cruciate ligaments as well as the surrounding muscle tendons are most taut. [26]

2.3.1 Ligaments of the knee joint

The ligaments of the knee are divided in extracapsular (outside the joint capsule) and intracapsular (inside the joint capsule).

The extracapsular ligaments (figure 1.1, 1.2) are:

- The patellar ligament, placed on the anterior side of the patella, is the continuancy of the quadriceps tendon inserted on the tibial tuberosity. This ligament gives the patella its mechanicall leverage and has important role in keeping the alignment of the patella relative to the patellar articular surface of femur.
- The lateral collateral (fibular) ligament extends from the femoral lateral epicondyle to the head of fibula, thus protecting the lateral side from an inside bending.
- The medial collateral (tibial) ligament extends from above the medial femoral condyle to the medial tibial condyle, thus protecting the medial side from an outside bending force. At its midpoint, the ligament's fibers are strongly attached to the medial meniscus. The tibial collateral ligament is weaker than the fibular collateral. Both collateral ligaments are tight when the knee is extended.
- The oblique popliteal ligament strengthens the posterior side of the capsule and is a tendinous expansion of the semimembranosus muscle. The ligament extends posteriorly from the medial tibial condyle towards the lateral condyle of the femur.
- The arcuate popliteal ligament extends from the posterior aspect of the fibular head and spreads towards the posterior surface of the joint. It strengthens the capsule posterolaterally. [26]

The intracapsular ligaments (figures 1.1, 1.2) are located in the center of the joint capsule, cross each other obliquely but are outside the synovial cavity. They restrict extreme tibial rotation against the femur over 10°.

- The anterior cruciate ligament (ACL) extends from the lateral condyle of the femur to the anterior intercondular area of the tibia. It limits posterior rolling of the femoral condyles during flexion as well as hyperextension of the knee.
- The posterior cruciate ligament (PCL) is the strongest and extends from the medial condyle of the femur to the posterior tibial intercondular area of the tibia. It limits anterior rolling of the femur during extension as well as hyperflexion of the knee. [26]

The two menisci (medial and lateral) are described as fibrocartilagenous plates firmly attached on the tibial plateau, serving as shock absorbers as well as deepening the articular surfaces of tibia for articulation with the condyles of the femur. Their peripheral border is thick while their medial border concave and thin. [10] Their anterior borders are joined by the transverse ligament of the knee. The medial meniscus is broader posteriorly and C-shaped. The lateral meniscus is almost circular, smaller and more movable on the tibial plateau than the medial meniscus.

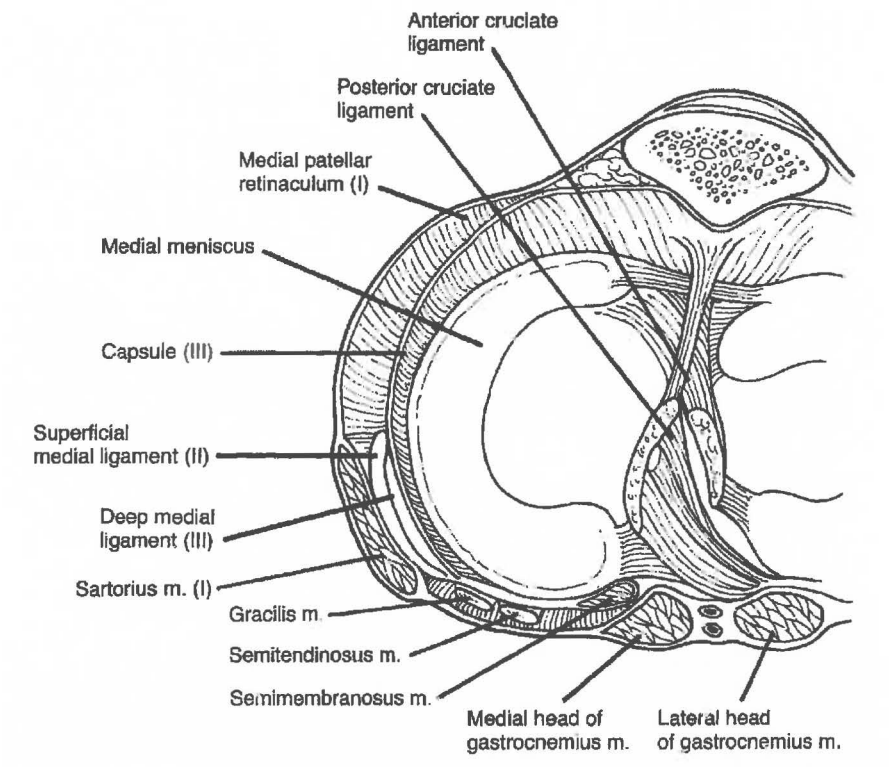

Figure 1.1: Cross section of the medial side of the knee. [29]

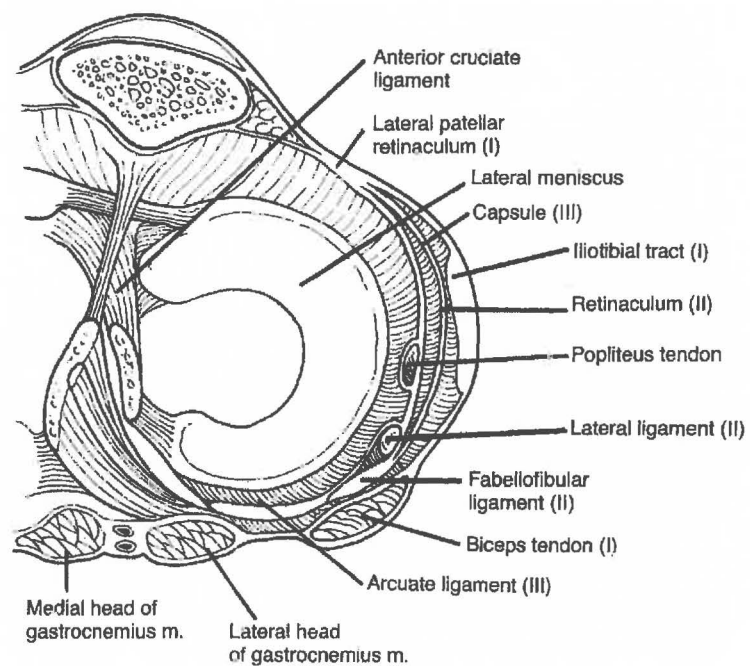

Figure 1.2: Cross section of the lateral side of the knee. [29]

2.3.2 Muscles surrounding the knee joint

Table 1: Muscles surrounding the knee joint. [26]

Muscle	**Origin**	**Insertion**	**Action**
Sartorius	ASIS	Superior medial surface of tibia	Hip F, ABD, ER; Knee F
Quadriceps femoris			
Rectus femoris	AIIS and ilium superior to acetabulum	Through common quadriceps tendon to the base of patella; indirectly via patellar ligament to the tibial tuberosity. Medial and lateral vasti also attach to patella and tibia via aponeuroses.	Knee E. Rectus femoris also helps iliopsoas in hip F
Vastus lateralis	Greater trochanter and lateral lip of femoral linea aspera		
Vastus medialis	Intertrochanteric line and medial lip of femoral linea aspera		
Vastus intermedius	Anterior and lateral		

	surfaces of femoral shaft		
Gracilis	Body and inferior pubic ramus	Medial superior border of tibia	Hip ADD, knee E
Tensor of fascia lata	ASIS, anterior part of iliac crest	Iliotibial tract attached to tibial lateral condyle	Hip ABD and IR.
Semitendinosus	Ischial tuberosity	Medial surface of superior part of tibia	Hip E, knee F and leg IR when knee is flexed
Semimembranosus		Posterior part of tibial medial condyle	
Biceps femoris	Long head: ischial tuberosity Short head: linea aspera and lateral femoral supracondular line	Lateral side of fibular head	Knee F and leg ER when knee is flexed. Hip E when walking.
Gastrocnemius	Lateral head: lateral aspect of lateral femoral condyle Medial head: surface superior to femoral medial condyle	Posterior surface of calcaneous via calcaneal tendon	Ankle PF when knee is extended, knee F
Plantaris	Inferior end of lateral supracondular femoral line, oblique popliteal ligament		Assists gastrocnemious in ankle PF

Popliteus	Femoral lateral condyle and lateral meniscus	Posterior surface of tibia	Knee F, leg IR

It has been noted by authors [19] [27] [4] that vastus medialis is divided in vastus medialis oblique (VMO) and a more vertical component, vastus medialis longus (VML), which act as two distinct functional units due to their different fiber orientation. The VMO is more oblique than the VML thus giving a mechanical advantage to the medial stabilisation of the patella. In contrast with VML, VMO does not extend the knee, but it is active throughout the whole extension movement to keep the patella in the center of the femoral trochlea. [19]

3. Movements of the knee joint

The main movements of the knee are flexion and extension, taking place in a coronal axis. From the zero position (position of zero extension), the range of flexion is approximately 140° (active movement). It must be noted that the hip joint must be flexed when measuring knee flexion, so that rectus femoris does not limit the movement. Hyperextension is abnormal movement beyond the zero position. [18] The axis around which the motion takes place though, shifts forward during extension and backward during flexion. [10]

Flexion and extension movements are accompanied by slight rotation. When the thigh is fixed, tibial internal rotation against femur accompanies knee flexion, where, when the leg is fixed, femoral external rotation against tibia accompanies knee flexion. Concerning knee extension, when the thigh is fixed, there is external rotation of tibia against femur and when the leg is fixed, there is internal rotation of femur against tibia. [18]

When the knee is extended in erect position, it passively "locks" due to the medial rotation of femur against tibia. This enables the lower extremity to be a strong column which bears all the body weight in standing. The popliteus is the muscle that "unlocks" the knee by rotating femur lateraly against the tibial plateau about 5°. [26]

4. The patellofemoral joint

4.1 The patella

The patella is the largest sesamoid bone in the human body. It is flat with triangular shape, located within the patellar ligament and articulating with the femur to form the patellofemoral joint. The role of the patella is to protect the anterior part of the joint and to increase the mechanical advantage of quadriceps muscle by providing additional leverage, since it places the quadriceps femoris tendon more anteriorly. [10]
The convex anterior surface of the patella is covered by an expansion of the quadriceps femoris tendon which continues caudally with fibers from the patellar ligament. It is separated from the skin by a bursa. [10] The posterior surface is divided in five facets, corresponding to the articulating surface with the femur. The geometry of these facets, superior, inferior, medial, lateral and odd vary between individuals and may affect the patellar tracking. [19]
The superior border gives attachment to the rectus femoris and vastus intermedius, where, the medial and lateral borders give attachment to vastus medialis and vastus lateralis respectively. The apex (inferior part of the patella) is directed downwords and gives attachment to the patellar ligament (figure 2). [10]
Three ligaments, the patellofemoral, patellotibial and patellomeniscal lie under the retinaculum. The patellofemoral ligament forms the primary restraint to patellar lateral translation, while the patellomeniscal being less useful and the patellotibial almost not useful functionally. [19]
The articular cartilage of the patella is the thickest in the human body, which signifies the stresses that the joint overgoes. [11]

4.2 Patellofemoral joint biomechanics

4.2.1 Stabilisation of the patella

There is a natural tendency of the patella to track laterally due to the anatomical structure of the joint. A static limitation to this tendency is provided by the lateral aspect of the femoral trochlea which extends more anteriorly than the medial aspect.

This means that the bony structures of the patellofemoral joint provide a natural stability when the patella lies within the borders of the trochlea (in 20-30° knee flexion). After this point there is no bony support and stability is achieved passively by the joint capsule and the medial and lateral retinaculum. [19]

The active stabilisation of the patella is achieved by the quadriceps muscle and mainly by the vastus medialis muscle. [19]

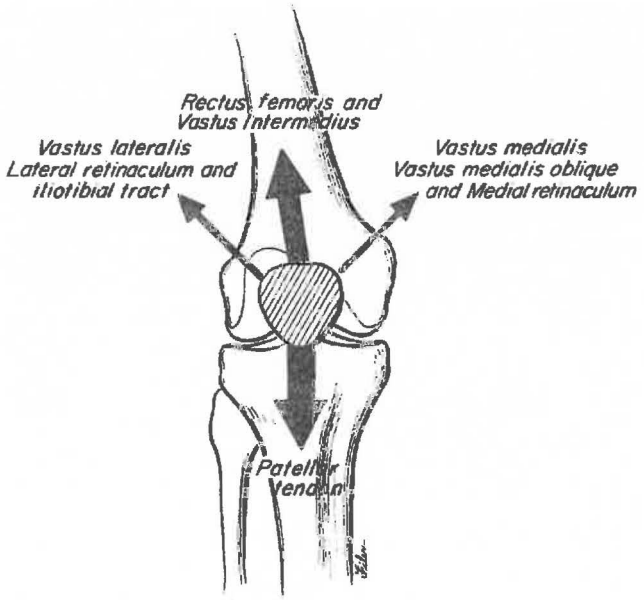

Figure 2: Forces and constraints on the patella during function. [9]

4.2.2 The patellar tracking

Patellar tracking is the term used to describe patella's motion during knee flexion and it's articulation with the femur. The function of this tracking system is to intensify the function of quadriceps in different static and dynamic activities, thus affecting the magnitude and distribution of forces as well as the contact pressures at the patellofemoral joint. Abnormal patellar tracking could lead to uneven distribution of otherwise normal patellofemoral loads, thus increasing the stress on one or more structures of the joint, contributing to development of patellofemoral pain. [19]

In a relaxed knee, the lower third of the patella articulates with the femoral trochlear surface and from full extension to full flexion glides about 7cm caudally on the femoral condyles. [12] During flexion, the patella moves medially and caudally, liing within the intercondular notch until 130° of flexion, when it starts to move laterally again. With increasing knee flexion, the articulating surface of the patella moves

superiorly, the patella moves laterally and a greater area of patellar articular surface comes in contact with the femur leading to an increased load. [4] So, patellofemoral contact area increases with flexion, with the contact pressure reaching maximum at 80-90° of flexion. [19] This larger contact area allows forces to scatter, with any alterations in the mechanics of the joint leading to increased forces on decreased area of contact, threatening the health of the patellar articular cartilage. [28] During extension, the patella moves supero-laterally, along the line of pull of quadriceps muscle.

The patella's medio-lateral glide depends on the direction of the net forces produced by the quadricep femoris muscle, particularly by the vastus medialis obliquus and vastus lateralis components. [12] [4] The patella tends to be pulled laterally by the vastus lateralis muscle, while the vastus medialis obliquus opposes this lateral pull, keeping the patella centered in the patellofemoral groove (figure 7). [12]

4.2.3 Forces on the patellofemoral joint

The magnitude of the patellofemoral joint (PFJ) reaction force (load) depends on the angle of knee flexion, the quadriceps muscle and the patellar tendon tension, as well as the distribution of load which is related to patellar tracking. [12] [19] Compressive force at the PFJ is 0.5 times the body weight during normal walking, increasing up to over three times the body weight during stair climbing. [12] In extreme flexion, subpatellar pressure may rise to 20 times that of body weight. [30] The lateral anatomical structures of the patellofemoral joint are anatomically much stronger than the medial ones, so any imbalance in the forces will cause the patella to move laterally. [12] [4]

Patellofemoral compression increases with knee flexion during weight bearing and there are two reasons for this. Firstly, with increased flexion there is changed orientation of force vectors and, secondly, as flexion increases there is a larger amount of quadriceps tension needed in order to resist the flexion moment of body weight. [12] Compression at the patellofemoral joint is the vector sum of tension in the quadriceps muscle and the patellar tendon. In extended position, the compression force is small because tension in the muscle and tendon act almost perpendicularly to the joint (figure 3). With increased flexion, the compression force

increases due to changed orientation of quadriceps and patellar tendon force vectors and increased tension requirement on quadriceps to maintain body position. [12]

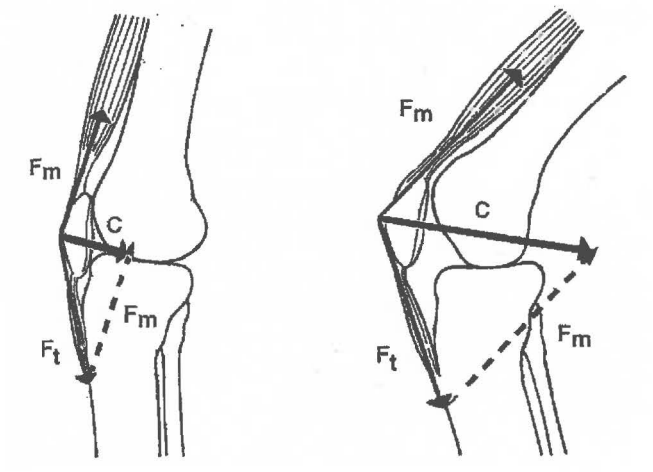

Figure 3: Representation of the vector sum of quadriceps and patellar tendon tension with increasing knee flexion. [12]

4.2.4 The Q-angle

The angle between the femoral and tibial bone is referred clinically as the Q-angle, with the letter Q deriving from "quadriceps" muscle. This angle is assesed by drawing a line from the ASIS to the center of the patella and a second vertical line passing through the center of the patella to the tibial tuberosity, thus representing the intersection of line of pull of quadriceps and the patellar tendon (figure 4).

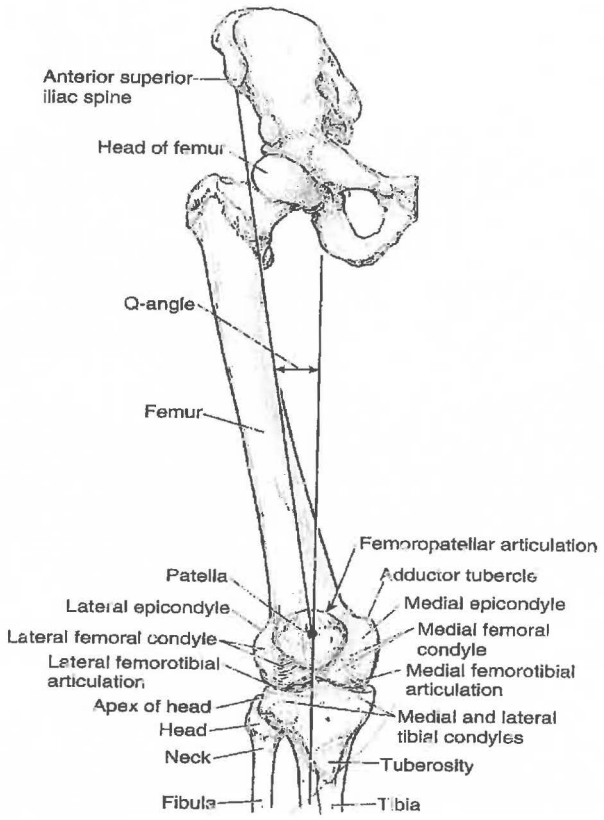

Figure 4: Assessment of the Q-angle. [26]

A normal value for a male adult is 14° (+/-3), where for a female 17° (+-3), owing this difference to the wider pelvis of females. The biomechanics of the patellofemoral joint is also affected by the Q-angle. [35] [26]

When Q-angle is normal, the middle of the knee joint is placed directly under the femoral head, centering the line of weight bearing in the intercondular region of the knee. A medial angulation of the leg

in relation to the thigh, in which the Q-angle becomes small, is called genu varum or bowleg. In this situation, the line of weight
bearing falls medially to the center of the knee causing increased pressure on its medial side, resulting in damaging of the knee cartilage and fibular collateral ligament overstressing. The opossite situation where there is lateral angulation of the leg in relation to the thigh is called genu valgum or knock-knee. The weight barring line falls laterally to the center of the knee, this time causing overstressing of the tibial collateral ligament as well as damage of the knee cartilage (figure 5). There is also caused abnormal patellar articulation with the femur due to the fact that the otherwise normally laterally pulled patella by the vastus lateralis tendon, is pulled even more towards the lateral side when the leg is extended, eventually causing damage to the femoropatellar articular cartilage. [26]

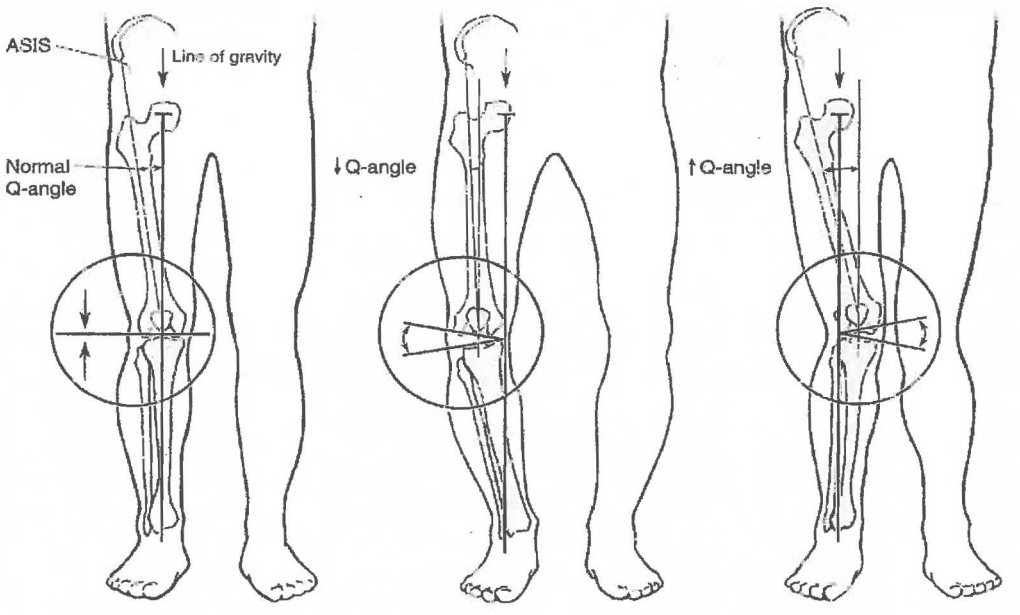

Figure 5: Representation of normal tibiofemoral alignment, genu varum and genu valgum. [26]

5. Chondromalacia patellae

5.1 Definition and symptomatology

Chondromalacia patellae is a state of erosion and fragmentation of the patellar cartilage resulting from misalignment of the patella as it slides over femur (figure 6). The cartilage becomes abnormally thin and soft resulting in exposure of the

underlying bone. [30] Synonyms include patellofemoral joint syndrome (PFJS) and anterior knee pain. Chondromalacia patellae belongs to the "umbrella" term patellofemoral pain syndrome (PFPS), used to embrace all peripatellar or retropatellar pain in the absence of other pathology. PFPS is one of the most common conditions involved in the management of sport injuries, acounting for 2-30% of all presentations and being more common among young women. [4] [19] The incidence in the general population is reported as one to four with the proportion increasing in the athletic population. [24]

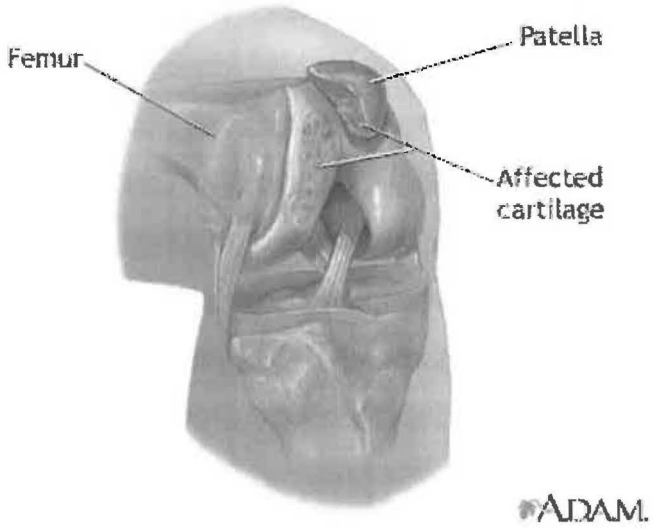

Figure 6: Representation of articular cartilage erosion in chondromalacia patellae. [38]

Patients with chondromalacia patellae report discomfort and pain in the posterior aspect of patella which is aggravated by activities such as running, jumping, squating, ascending or descending stairs and sitting for prolonged time with the knees flexed. The symptom is also aggravated by patella compression against the femoral condyles and by strong quadriceps contration. Some patients may also report a sense of "tightness" in the knee area or complain about crepitus, which may be present in 62% of involved population. There are also some cases where patients experience chronic joint clicking as well as "locking" of their knee, which must be differentiated though from meniscal locking or anterior cruciate ligament deficiency. (30) (19) (34) (31)

An observational study was elaborated by C Brushøj et al, with objectives of determining aggravating activities of acute anterior knee pain caused by overuse and

determining if acute anterior knee pain could be classified as a subgroup of PFJS. There were examined 30 army recruits with anterior knee pain and average duration of pain 4 weeks, using the pain severity scale (PSS), knee pain diagrams, standardised clinical examination, ultrasound and MRI examinations. The results showed that typical loading knee activities were the most painful (according PSS), while sitting with bent knees for prolonged time caused surprisingly little pain. The most common site of pain was perceived on the peripatellar area by 25 subjects (83%) as well as other synovial covered structures (fat pad of Hoffa 12 patients/40%, joint line 12 patients/40%) being involved on a lesser extent, with only 8 patients (27%) experiencing pain on the patellofemoral compression test. The researchers also concluded that acute anterior knee pain should be regarded as a subgroup of PFPS as both symptoms and clinical examination suggests this. [5]

5.2 Ethiopathogenesis

Under normal circumstances, the patella is pulled cranially on the femur on a straight line, after contraction of quadriceps. There are some factors though that contribute to increased patellofemoral joint (PFJ) load and abnormal patellar movement (patellar tracking) leading to damage of the patellar articular cartilage.

Factors that contribute to increased PFJ load could be divided in two categories: extrinsic and intrinsic. The ***extrinsic load*** is created by the body's contact with the ground which is moderated by the type of surface, type of footwear, body mass, speed of gait, number and frequency of loading cycles. [4] As mentioned on previous chapter, any increase in the degree of knee flexion during weight bearing activities, leads to an increase of PFJ load. When PFJ load is supranaturaly increased, it may lead to initiation of painful process.

Intrinsic factors can influence the magnitude as well as the distribution of PFJ load, with the later being conceptualized as patellar tracking. These factors could be further subdivided in remote and local. Remote factors include increased Q-angle, knee valgosity, increased internal rotation of the femur, increased subtular pronation, increased rotation of tibia and inadequate muscle flexibility (particularly the rectus femoris, ITB, hamstrings and gastrocnemius). In adolescent boys, subtalar pronation alone was found to be the single significant factor contributing to patellofemoral

pain. [24] Local factors include patella position (lateral tilt, lateral displacement, posterior tilt, rotation, patella alta), patella dysplasy, neuromuscular control of lateral and medial vasti (decreased strength, delayed onset of vastus medialis relative to vastus lateralis, altered tendon reflex, muscular imbalance) and soft tissue tension (tight lateral structures, loose medial structures, patella hypermobolity). [4] [34] [24] [31] Chondromalacia patellae may also be caused by direct or repeated trauma to the patellar area by a fall, blow or pressure from prolonged load on the knee such as weight training. [17]

A study was elaborated by L. Herrington, N. Rivett and S. Munro (2006) in order to define the relationship between the length of the ITB and the medio-lateral position of the patella by examination of 80 asymptomatic subjects (37male, 43 female). Assesment of ITB length was done using Ober's test and modified Ober test with extended knee and patella position was assesed by palpation. The authors found that in the group of 47 subjects with laterally displaced patellae, patella position had a moderate correlation to ITB length measured by modified Ober's test and poor correlation to ITB length measured by Ober's test, leading them to the conclusion that there is only partial relation between lateral patellar displacement and ITB length. [13]

Z. al-Rawi and AH Nessan (1997) studied the relationship between knee joint mobility and chondromalacia patellae by comparing 110 healthy control group individuals with 115 symptomatic individuals. Chondromalacia patellae were bilateral in 57% of their patients, occuring more frequently in the longer leg and associated with quadriceps muscle wasting in 50% of patients. Flat feet and back ache were also reported more often inpatients compared with the control group. The degree of joint mobility was scored on a scale 0-9. The researchers found that there were more hypermobile knees among knee joints with chondromalacia patellae in comparison with the knees of the healthy group which lead them to the conclusion that hypermobility of the knee joint may be a contributing factor in the pathogenesis of chondromalacia patellae. [1]

M J Callaghan and J A Oldham (2004) investigated the atrophy and weakness of quadriceps femoris on 57 patients with PFPS and 10 healthy control group individuals, measuring muscle cross-sectional area by ultrasound scanning and peak extension torque by use of dynamometer. The study revealed a 3.38% difference in

cross sectional area between affected and unaffected limb in PFPS patients and a 1.31% difference between dominant and non dominant limb in the control group. The peak torque difference between affected and unaffected limb in PFPS patients was 18.4% and difference between dominant and non dominant limb in the control group 7.6%. These results revealed that cross sectional area difference between groups was not significant, whereas more significant was the peak torque difference, indicating that muscle strength may not be related to muscle size and helping to re-evaluate the amount of quadriceps atrophy in PFPS. [7]

5.3 Sources of pain

There is a number of intra- and extra-articular components that may generate neurosensory signals leading to perception of pain. While it is accepted that patellofemoral articular cartilage can not be a direct source of pain, damage to the cartilage may lead to mechanical or chemical irritation of the synovium or association with subchondral bone erosion which leads to pain. Peripatellar synovitis must be considered as one of the main causes of patellofemoral pain since large amount of nerve endings are found in the synovia. Due to its reach innervation and its relationship with the synovium, the infrapatellar fat pad together with the lateral and medial retinacula have been implicated as forceful sources of pain. [19] [4]

5.4 Conservative treatment

Most PFJS can be successfully managed with physical therapy, attempting to restore the normal pattelar tracking system through active and/or passive interventions, resulting in a decrease of the patient's symptoms. The therapist's first priority though in management of the patient should be the reduction of pain through rest from aggravating activities, ice applications and electrotherapeutic modalities. Mobilization techniques, acupuncture and taping may also be helpful. [4]

5.4.1 History and clinical examination

In the history the therapist should elicit the history of pain onset, the area of pain, the type of aggravating activities and the pain's behaviour, as well as any swelling or joint clicking. [19]

The goal of clinical examination is to determine the underlying factors (extrinsic and intrinsic) that contribute to the genesis of the problem so that appropriate treatment plan can be followed out. The patient's posture in standing position is initially examined in front, back and side views for assesment of lower extremity alignment as well as other postural contributing factors. Postural examination is followed by dynamic (gait) examination, in order to evaluate the effect of muscle action on the static mechanisms and to reproduce the patient's symptoms. First is examined the less stressful activity of normal walking, which may be followed by more stressful activities such as stair climbing, squat and single leg squat. [4]

The next step is examination in lying position where the therapist, through palpation, is able to assess painful areas, structures under stress as well as restrictions to optimal range of movement (ROM). Examination should include joint line palpation, meniscal and ligamental tests, muscle length (particularly psoas, rectus femoris, TFL, hamstrings and gastrocnemius), tests for tightness of lateral structures (ITB length and lateral retinaculum) as well as foot posture and femoral nerve mobility assessment. A crucial component in examination by palpation is patellar position in static and dynamic manner with relation to the femur. In static manner, the optimal patellar position is the one where the patella is parallel to the femur and in the midway between lateral and medial condyles when the knee is flexed to 20°. [24] Medial and lateral as well as superior and inferior borders should be at the same height and the long axis of patella parallel to the long axis of the femur. In dynamic manner, when quadriceps contracts, patella should move cranially without any mediolateral displacement, rotation or tilting. [19]

5.4.2 Treatment techniques

Patellar taping aims in correcting the abnormal position of the patella in relation to the femur, thus improving patellar tracking. This is achieved by provoking a

sustained stretch and making use of the creep phainomenon occuring in viscoelastic tissue when constant load is applied. Due to the fact that this technique reduces patellofemoral pain immediatelly, it is appropriate to use it while other contributing factors are being corrected. Taping may unload painful structures, provide mechanical advantage to quadriceps muscle, speed the onset timing of VMO relative to vastus lateralis and reduce pain. For training to be effective, the patient must not feel pain when training, as pain has an inhibitory effect on muscle function. [24] The tape is applied with the knee fully extended and the quadriceps relaxed. The choice of taping technique is based on the assessment of patellar position (gliding, tilting, rotation) and the achievement of pain reduction. Patellar taping is unique for each patient, with the corrected components, the order of correction and the tension of the tape being based on the assesment of patellar position. The worst component should be corrected first and taping should be followed by re-evaluation of painful activity. The tape should always improve the patient's symptoms immediately, and if not, then the application order or the components corrected should be re-examined. The area of application should be shaved and a protective barrier should be applied between the skin and the rigid strapping tape in order to provide a protective layer to the skin. Acute cases of patellofemoral pain need tape application 24 hours a day until the condition settles. The tape time is then gradually reduced. [19] [4]

Stretching exercises should be included in the treatment program. The included muscles should be the hamstrings, rectus femoris, gastrocnemius and TFL with the ITB. Stretching of tight lateral structures is beneficial and can be achived in side lying position with the knee flexed. The therapist glides the patella medially, using a sustained stretch by the heel of his hand. The patient can also be taught how to stretch tight structures himself. [19] [4]

Physiotherapy interventions have mostly focused on **VMO retraining and strengthening** due to the fact that dysfunction of the VMO may result in lateral patellar shift. [19] [24] [31] [4] Current evidence to support imbalance in vasti activation (either decreased activation of VMO or enhanced activation of vastus lateralis) though is controversial since researches have revealed that VMO can not be exercised in isolation and that no exercise is preferential for particular activation of the VMO. [25] [4] [28] [19] On the other hand, studies have shown that disrupted activation of the vasti may take the form of delayed VMO activation in relation to VL,

due to the fact that VMO has smaller cross-sectional area and needs feedforward enhancement of its excitation level in order to track the patella optimally. [19]

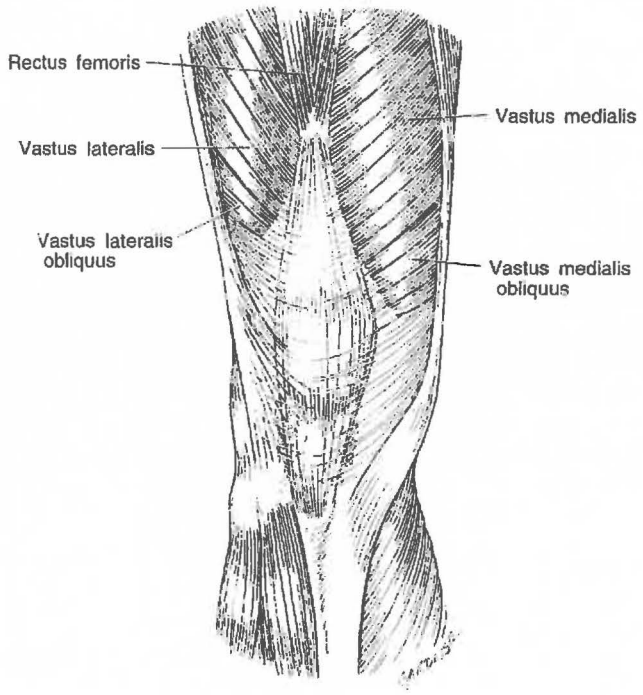

Figure 7: Manifestation of the more distal vastus medialis insertion compared to that of vastus lateralis. [9]

Furthermore, emphasis or selective training of VMO is possible and can affect an individual's activation pattern. [28] [15] Other authors have theorized that generalized quadriceps strengthening may bring VMO up to the "threshold" needed for adequate patellar tracking without selective training of the VMO. [28]

Generalized **quadriceps strengthening** exercises are effective in the management of chondromalacia patellae. [24] [3] [36] [4] These exercises should consist of isometric contractions, non-weight bearing/open kinetic chain exercises, with or without elastic resistance, within range of 30-0° and straight leg raises. Weight bearing/closed kinetic chain exercises (squat, leg press etc) should start as long as the activities are not painful due to the fact that closed kinetic chain exercises in greater degrees of flexion, may lead in increased compressive forces on the PFJ. [32][28]

Souza (2000) suggests that both open and closed kinetic chain exercises can be effective in treatment of chondromalacia, with some small advantages to closed chain approaches. [32] Steinkamp et al. (1993) found PFJ stress to be greater in leg extension exercise within 0-30°, in comparison with leg press. They also found increased PFJ stress in 60-90° of leg press compared with open chain leg extension

exercise. The result indicates that the therapist should use open chain leg extension through full ROM with caution in patients with chondromalacia patellae. [28]

Bakhtiary and Fatemi (2008) compared the effect of straight leg raise (open chain) and semi-squat on treatment of chondromalacia, indicating that semi-squat exercises are more effective than straight leg raise in the treatment of patellar chondromalacia. [3]

From the above we conclude that strengthening exercises could include both open and closed chain patterns that limit PFJ stress forces. Closed chain exercises should be performed within 0-30° extension and the remainder of the ROM can be strengthened in open chain position.

A useful starting exercise is knee flexion and extension within the first 30°, in standing position with feet pelvis width apart and equal weight bearing. [19] [28] Since treatment also aims in the patient becoming able to climb stairs without pain, the patient should then practice in stepping up and down on a small step. The exercise could be performed in front of a mirror so that patient has information concerning the proper extremity alignment. For further progression the patient may move to a larger step, initially decreasing the number of repetitions and slowly increasing them again. It must be kept in mind that, concerning all exercises, attention should be paid on quality and not quantity. Therefore, the number of repetitions should depend on muscle fatique. [19]

Schulties et al (1998) studied the EMG activity of VMO, VL, semimembranosous, semitendinosous and biceps femoris during four elastic resistance closed chain exercises: front pull, back pull, cross over and reverse crossover. Elastic resistance was applied to the uninvolved extremity, while the involved extremity stabilized the body weight. EMG showed that the highest hamstring/quadriceps ratios on the involved extremity were found during front pull and crossover exercises, suggesting that this type of exercising can be used early in the rehabilitation program in order to promote normal proprioceptive and functional patterns of musculature, balance and coordination, as well as resulting in greater strength gains than squats and stair stepping. [28]

Hip muscle strengthening, particularly the hip abductors and external rotators, is important in order to improve lateral pelvis stability and controling hip internal rotation, thus decreasing valgus vector force applied on the knee and minimizing

unnecessary loads. [19] If the gluteus medius is working well, there is less activity on TFL, leading to a decrease in the lateral pull of the patella from the ITB. [28] Gluteus medius training may initially be performed in non-weight bearing positions, progressing to weight bearing positions. In weight bearing, posterior gluteus medius may be trained by the patient standing to the side of a wall, with the leg closest to the wall (uninvolved) being flexed at the knee so that the foot is not on the ground. The patient is asked to push this leg against the wall, while externaly rotating the weight bearing (involved) leg without moving the foot or the pelvis. [19] [4]

Correcting abnormal foot pronation should improve the stability of the foot during push off phase and decrease the valgus vector force that has been created to the knee. This can be achieved actively by teaching the patient how to train the supinators of the foot by lifting the longitudinal arch while keeping the great toe on the ground and then pushing the first metatarsal and great toe on the ground. [19] Another useful exercise is the formation of the "small foot", by the toes being stretched and closely fitted to the floor while being pulled together with the metatarsal heads towards the heel, in order to increase afferentation signals from the sole, improve the position of the foot and the body's stability. [21]

Abnormal foot pronation can be passively corrected by the use of in-shoe foot orthoses. [4]

5.5 Surgical treatment

The need for surgical treatment of chondromalacia patellae has been greatly reduced due to the broad availability of physiotherapeutic interventions. Brukner and Khan note that poor surgical outcomes have been reported and patellofemoral pain is often worsened after surgery and that, to their knowledge, there has been no surgical randomized trial showing effectiveness of treatments such as patellar chondroplasty or lateral retinacular release. [4] Bahr and Maehlum (2004) quote that surgery is only indicated if there are clearly documented findings implementing patellar dislocation or a tilted or laterally shifted patella. [2] Researchers are studying the effect of surgical treatment of the cartilage with promising results for patients with significant cartilaginous changes. [2]

An arthroscopic excision of damaged cartilage was described by Zorman et al. (1990) with satisfactory results and absence of major complications in a follow up of 12 months. [37]

Sprengel and Franke (1990) re-examined 150 knees after surgical treatment for chondromalacia patellae, finding good and very good results in 52.7%. The authors note that due to 82% good results in lateral release, lateral release operation can be recommended. [33]

Special part

1. Methods

The clinical part of this study took place at Ustředni Vojenská Nemocnice Praha (Prague Military Hospital) in the period 21/01/2008-1/02/2008. The case study was elaborated with accordance of a 21 year old male patient with representation of retropatellar pain on his left lower extremity. The meetings included five therapy sessions within two weeks period. Information about the patient's accordance for examination and therapy is available upon request.

After thorough clinical examination for the establishment of the diagnosis, each treatment session included 20 minutes of magnetotherapy application for analgesic and regeneration effect, proceeding with strengthening exercises. Soft tissue techniques (transverse gliding, friction) were used for stretching tight lateral soft tissue structures, as well as post isometric relaxation technique (PIR) for relaxation of hypertonic muscles. Post facilitating stretch technique (PFS) was performed for elongation of shortened muscles, as well as mobilisation techniques by Lewit for mobilisation of restricted joints.

Improvement of foot longitudinal arch, proprioceptive information and muscle coordination were exercised by sensory motor stimulation (SMS) by Janda, starting with formation of "small foot" and proceeding with postural correction exercises. Balance exercises were initially performed on the ground, proceeding to more complex patterns such as half steps and lunges, also using the aid of wobble boards and rocker boards.

Quadriceps muscle reeducation and strengthening exercises were provided both in open and closed kinetic chain patterns, in concentric and eccentric manners. Straight leg raises and squats as well as exercising against elastic resistance were included in the strengthening program. For more complex patterns, stability trainers of increasing difficulty were also used. Finally, hip abductors and particularly gluteus medius muscle were strengthened in the same manner by the use of elastic resistance exercises.

2. Anamnesis

Examined person: O.K (Male)
Date of birth: 1986
Diagnosis: Left knee chondromalacia patellae

History of present problem:
His problem occurred 6 months ago, after a basket-ball game, when he felt pain around his knee and underneath the patella and could not step on his foot. Before and during the game there was no injury nor hit on his knee.
He visited a doctor 4 months ago, who gave him antiarthrotic medications which he took for 3 months but had no effect. He continued having the problem and stopped taking the medication.
He visited another doctor on 20/12/08 who diagnosed the problem and prescribed him rest, magnetotherapy and physical therapy. He also prescribed "Erectus" intraarticular injections (5 shots in total, had the first one on 20/12 and 1 per week since then) and "Gool" powder (1 every morning). Patient mentions that after having the first 2-3 injections, pain subsided but not completely disappeared.

Status presens:

- He feels little pain underneath the patella when he walks, but especially when he goes up the stairs. The pain re-occurs when he plays basket-ball or running.
- Pain perception according patient (1-10 scale): When walking normally he would estimate the level of pain as "0" but if he walks long distance and makes his leg tired, "3". When he goes up the stairs, "3" as well.
- He wants to go back to sports activity as soon as possible.
- Height: 1.86m
- Weight: 85 kg

Personal anamnesis:

- Asthma bronchiale.
- Hernia operation on left side when he was 10 years old.

- Right fibula fracture (a small piece was wripped off) when he was 14 years old.
- 1 month ago he felt pain on his right Achilles tendon after fast and longlasting walk. He visited the doctor on 24/12/07, who observed no swelling nor redness and told him to protect his leg by not getting it tired and also provide stretching exercises for Achilles tendon.
- Never used orthesis or tapping.

Family anamnesis:

- Grand parents have heart problems and hypertention.
- Parents are healthy.
- No other members of his family ever had joint or spine problems, apart from his brother who complained about elbow pain previous week.

Social anamnesis:

- Works in advertising agency and does a sitting job in front of PC, about 4-5 hours per day. The position of the computer is in front of him, so he sits straight on the screen.
- Not married.
- Lives with his parents in 2 floor house with stairs (about 30 stairs), which he needs to go up and down many times per day.

Hobbies:

- Basket-ball playing
- Running

Medication:

- Symbicort (for asthma)
- Erectus® intraarticular injections (for knee problem)
- Gool® powder (for knee problem)

Allergies:

- Has allergy in dust and flowers.

Abuses:

- No smoking, occasionaly alcohol.

Previous rehabilitation:

- No.

Note: Should have started his therapies on 21/1/08, but he came late and had only 20 minutes of magnetotherapy.

Doctor's examination and evaluation (translated)**:**

Patient was examined on 20/12/07 at UVN orthopedic outpatient department by MUDr Ales Puchmeltr.

- Has pain on left knee under patella for last six months. No injury. He can manage the squat with painful "klik" sound. Conservative care was carried before with no improvement. He wants to do sport.

Examination result: knee without swelling and filling, tests for ligaments are negative, movement without restriction-not painful, femoropatellar joint tests painful, meniscus tests negative.

X-ray result: normal without abnormalities, except small patella dysplasy.

Diagnose: M 224 chondromalacia patellae

Therapy: Erectus® intraarticular injections

Recommended therapy: another 5 Erectus® injections, Gool® powder, quadriceps stretch, RHB-PT and individual exercises.

3. Clinical examinations

X-ray of his left knee on 20/12/07. Findings: apart from slight patella dysplasy, there were normal findings. There was no swelling or filling in the joint. Free and not painful movement of the knee.

4. Initial kinesiologic examination

1) General appearance:

- Patient feels and looks very good, walks without limping, dresses and undresses without problems
- He is very cooperative and easy going.

2) Posture evaluation:

a) Anterior view

- Both feet in pronation (supplement 2, picture 2A).
- Out-toeing feet.
- Both feet flat longitudinal and transverse arch, especially on left extremity (supplement 2, picture 2A).
- No knee valgosity/varosity.
- Both hips in ER.
- Right lower extremity in slight ABD.
- Right shoulder slightly depressed.
- Dominant hand: right
- Romberg tests (I,II,III): negative
- Vele test: positive

b) Posterior view

- Weight barring on inside of feet (supplement 1, picture 1A).
- Heels and Achilles tendons symmetrical.
- Left thigh contour is thicker.
- Subgluteal lines symmetrical.
- Left trunk outline more concave.
- Both scapulas adducted.
- Right scapula lower.

c) Side view

- Head in slight anteflexion and protraction.
- Lower C-spine kyphotic.

- Th-spine slight hyperkyphosis on upper part.
- L-lordosis flat.
- Pelvic posterior tilt.
- Knee joint position optimal.

3) Trendelemburg test:

Both extremities negative.

4) Gait evaluation:

- No trunk rotation.
- No arm synkinesis.
- Good control of speed and balance.
- Good stride and step length.
- Good pelvic movement.
- Provides slight ABD in right hip joint when walking.
- Bad heel contact and toe lift off. He puts his weight more on the inside of his feet and lift off phase takes more by the head of proximal phalanges than by the toes.
- Backward walking: good.
- Tip-toe walking: good.
- Heel walking: good.

5) Active movement:

- Squat with both legs not painful
- Left leg squat painful (he feels the pain underneath the patella)
- Left quadriceps isometric resistance: test was provided with the patient in sitting position. He felt pain when he pressed hardly against my hand with his knee in 90, 60 and 30 degrees flexion. Pain was around and underneath the patella.
- Right quadriceps isometric resistance: not painful
- Hamstrings isometric resistance: both extremities not painful

6) ROM orientation examination by active movement:

a) Ankle joint

	Right extremity	Left extremity
PF	40°	40°
DF	10°	10°
Inversion	25°	25°
Eversion	15°	15°

b) Knee joint

	Right extremity	Left extremity
F	130°	120°
E	130° (return to zero position)	120° (return to zero position)

c) Hip joint

	Right extremity	Left extremity
F with knee E	80°	60°
F with knee F	120°	110°
E	15°	15°
ABD	45°	45°
ADD	20°	20°
IR	25°	20°
ER	40°	40°

7) ROM orientation examination by passive movement:

a) Ankle joint

	Right extremity	Left extremity
PF	45°	45°
DF (with knee E)	15°	10°
Inversion	30°	25°
Eversion	20°	20°

b) Knee joint

	Right extremity	Left extremity
F	130°	120°
E	130° (return to zero position)	120° (return to zero position)

c) Hip joint

	Right extremity	Left extremity
F with knee E	85°	70°
F with knee F	120°	120°
E	15°	15°
ABD	45°	45°
ADD	25°	20°
IR	30°	20°
ER	40°	45°

8) Joint play examination (by Lewit) [20]:

	Right extremity	Left extremity
Calcaneous	Normal	Normal
Lisfrank joint	Normal	Restricted in cranial direction
Talocrural joint	Normal	Normal
Knee joint	Normal	Restricted in dorsal direction
Patella	Normal	Restricted in caudal direction
Tibiofibular joint	Normal	Restricted in ventral direction

- Sacroiliac joint: springing test normal, Patrick's phainomenon normal

9) Palpation:

- Iliac crests symmetrical.
- Anterior superior iliac spines symmetrical.

- Posterior superior iliac spines symmetrical.
- Left patella slightly glided laterally.
- Left iliotibial band stiff and not flexible.
- Right triceps surrae hypertonus.
- Both Achilles tendons look the same and feel the same in palpation.
- Right Achilles tendon little painful in palpation (when providing the "s" technique).
- Subcutaneous tissues and fascia mobility: both extremities normal.
- Passive extreme flexion of knee joint: both extremities not painful.
- Pressure of patella against knee: both extremities not painful.
- Medial and lateral borders of patella: both extremities not painful.

	Right extremity	Left extremity
Functional length	87cm	87cm
Anatomical length	95cm	95cm
Thigh circumference 15cm above patella	48cm	48cm
Knee circumference	37cm	37cm
2 scale measurement	44kg	41kg

Meniscus lession testing [6]:

- Apley test by compression: both extremities negative.
- McMurray test: both extremities negative.

Medial/lateral collateral ligament testing [6]:

- Apley test by traction: both extremities negative

Cruciate ligament testing [6]:

- Lachman test (for anterior cruciate ligament): Both extremities negative.
- Posterior Drawer test (for posterior cruciate ligament): Both extremities negative.

10) Hypermobility tests:

- Thomayer distance: grade A hypomobility, (5cm no contact with floor).

- Sachse test for knee joint: both extremities grade B hypermobility (3cm)

11) Muscle length tests (by Janda) [16]:

- Triceps surrae: both extremities normal (0)
- Hamstrings: left extremity limited (1)
- Iliopsoas: both extremities normal (0)
- Rectus femoris: left extremity limited (1)
- Tensor fascia latae: both extremities normal (0)
- Sartorius: both extremities normal (0)
- Adductors: both extremities normal (0)
- Piriformis: both extremities normal (0)

12) Muscle strength tests (by Kendall) [18]:

- Hip ER: left 4+, right 4+
- Hip IR: left 5, right 5
- Hip ABD: left 5, right 5
- Quadriceps: left 5, right 5
- Gluteus medius: left 5, right 5
- Gluteus maximus: left 4+, right 5
- Triceps surrae: left 5, right 5
- Hamstrings: left 5, right 5

13) Deep sensation examination

- Position sensation: normal
- 3D sensation: normal

Conclusion:

- Left hamstrings and rectus femoris in shortened position.
- Left hip external rotators in shortened position
- Weak external rotators in both extremities
- The problem may be caused by increased hip IR (not present), tibial IR, knee valgus (not present) or foot pronation. Due to obvious foot pronation and

longitudinal arch flatness, especially on left extremity, I believe that this is the reason that causes the problem.

- According to patient's condition before and after taking medication (Erectus-Gool), medication therapy has contributed a lot in having progress and decreasing pain.

5. Short term and long term plan

Short term plan:

- Decrease of pain.
- Improvement of left iliotibial band flexibility.
- Mobilization of joint blockages.
- Stretching of shortened muscles.
- Quadriceps reeducation and hip muscles strengthening.

Long term plan:

- Stability and balance improvement
- Correction of feet pronation and increase of feet longitudinal/transverse arch by active exercises and anatomical insole orthesis.

6. Rehabilitation

Day to day therapy

23/01/08

12:00-12:30 time was used for initial examination of the patient

12:30-12:50 magnetotherapy

Day to day therapy

25/01/08, 12:00-13:20

Present state:

- Patient feels good
- Pain perception (1-10 scale): maximum 2

Examination:

- Left patella joint play restricted in caudal direction
- Left tibiofibular joint play restricted in ventral direction
- Patella palpation not painful
- Left iliotibial band stiff
- Right triceps surrae hypertonus

Goal of today's therapy:

- Decrease of pain
- Joint mobilisation
- Longitudinal/transverse arch increase
- Quadriceps reeducation

Procedure:

- Magnetotherapy 20 minutes (12:00-12:20)
- Patella mobilisation technique in caudal direction (Lewit)
- Fibula mobilisation in ventral direction (Lewit)
- Hamstrings and quadriceps stretching by PFS technique.
- Patient in supine position: provides left extremity straight leg raise with hip ER, 2x10 repetitions (supplement 4, picture 4).
- Education in formation of "small foot", first passively/semi-actively/actively (supplement 3, pictures 3A and 3B).
- Correction of stance and posture for sensomotoric exercises.
- Sensomotoric exercises: education of corrected stance, half steps and lunges on the ground. Same exercises provided on rocker board and then on wobble board (supplement 4, picture 5).
- Reeducation and strengthening exercises: Patient stands with left leg on Thera Band blue stability trainer and provides small single leg squat. 2x5 repetitions. Exercise is not painful.
- Patient stands with his back on the wall and provides hip F and ER against Thera Band elastic resistance, 2x10 repetitions (supplement 5, picture 6).
- Patient is standing and provides hip E with small ER against Thera Band elastic resistance, 2x10 repetitions.

- Left quadriceps and hamstrings stretching by PFS technique.

Self therapy:

- Formation of "small foot".
- Left extremity straight leg raise.

Day to day therapy

28/01/08, 12:00-13:20

Present state:

- Patient does not feel pain on the knee when walking. Sometimes he feels little pain when he goes on stairs inside his house (pain perception "1").
- Felt small pain on right Achilles tendon when he provided "small foot" exercise at home, but he said that maybe was caused because he did the exercise mistakenly.

Examination:

- Left patella mobility restricted in caudal direction. Also crepitus feeling and sound at the end of range. Patient mentioned little pain when reaching the barrier.
- Left knee joint play: normal in all directions.
- Talocrural joint play: both extremities normal.
- Lisfrank joint play: both extremities normal.
- Right triceps surrae hypertonus and Achilles tendon a little painful in "s" palpation.
- Left iliotibial band stiff.

Goal of today's therapy:

- Decrease of pain.
- Pronation and longitudinal/transverse arch correction.
- Quadriceps reeducation and strengthening.

Procedure:

- Magnetotherapy (12:00-12:20)
- Right triceps surrae soft tissue technique (functional massage) and PIR for soleus and gastrocnemius
- Right Achilles tendon soft tissue technique ("s") but was little painful.
- Soft tissue technique for left iliotibial band.
- Hamstrings and quadriceps stretching by PFS technique.
- Patient in supine position: provides left extremity straight leg raise with hip ER, 2x10 repetitions.
- Patient in supine position: provides left extremity straight leg raise with hip IR, 2x10 repetitions.
- "Small foot" formation exercising.
- Correction of stance and posture for sensomotoric exercises.
- Sensomotoric exercises: education of corrected stance, half steps and lunges on the ground. Same exercises provided on rocker board and then on wobble board.
- Sensomotoric exercises: patient walks over rocker board, wobble board, blue Thera Band and red Thera Band stability trainers. Exercise repeated 6 times.
- Qudriceps reeducation strengthening: Patient stands with his back on the wall and provides hip F and ER against Thera Band elastic resistance, 2x10 repetitions.
- Hip abductors strengthening: patient is standing and provides hip E with ER against Thera Band elastic resistance, 2x10 repetitions.
- Patient stands with his back on the wall and slowly provides small squating (until 45 degrees of knee F approximately). Exercise is not painful. 2x10 repetitions.
- Hamstrings and quadriceps stretching by PFS technique.

Self therapy:

- Formation of "small foot".
- Left extremity straight leg raise with hip ER. Same exercise with hip IR.
- Small squating with his back on the wall.
- 20 minutes bicycle in slow speed and small resistance.

Day to day therapy

30/01/08, 11:30-12:50

Present state:

- Patient feels no pain on his knee even when going on stairs, but he feels little tension on his right Achilles tendon.

Examination:

- Left iliotibial band stiff and not flexible.
- Left patella mobility normal.
- Tibiofibular joint play normal on both extremities.
- Right triceps surrae normal tonus.
- Right Achilles tendon not painful on palpation.

Goal of today's therapy:

- Pronation and longitudinal/transverse arch correction.
- Quadriceps reeducation and strengthening.

Procedure:

- Magnetotherapy (11:30-11:50)
- Left iliotibial band soft tissue technique.
- Left hamstrings and quadriceps stretching by PFS technique.
- Patient in supine position: provides left straight leg raise with hip ER, 2x10 repetitions.
- Patient in supine position: provides left straight leg raise with hip IR, 2x10 repetitions.
- "Small foot" formation exercising.
- Sensomotoric exercises: education of corrected stance, half steps and lunges on the ground. Same exercises provided on rocker board and then on wobble board.
- Patient stands with his back on the wall and provides left hip F with small ER and knee E against Thera Band elastic resistance. 2x10 repetitions.

- Same exercises but patient is facing the wall and provides left hip E with small ER against elastic resistance, 2x10 repetitions.
- Patient stands with his back on Thera Band ball against the wall and slowly provides small squat, 2x5 repetitions (supplement 6, picture 8).
- Patient stands with his left leg on blue Thera Band stability trainer and with his right leg provide hip F with knee E against Thera Band elastic resistance, 10 repetitions (supplement 5, picture 7).
- Left quadriceps stretching by PFS technique.

Self therapy:

- Formation of "small foot".
- Left hip isometric F and ER with knee E and foot DF for vastus mediallis reeducation. Same exercise with hip IR for vastus lateralis reeducation.
- Small squating with his back on the wall.
- Hamstrings and quadriceps stretching.
- 20 minutes bicucle in small speed and low resistance.

Day to day therapy

1/02/08, 11:30-13:00

Present state:

- Patient had his last "Erectus" injection on Wednesday.
- He feels no pain on his knee during any activity.
- He did 15 minutes bicycle yesterday and when he finished did stretching. When he went to bed after 2 hours, he felt little twiching on his right Achilles.

Examination:

Final kinesiologic examination is described in following chapter.

Goal of today's therapy:

- Pronation and longitudinal/transverse arch correction.
- Quadriceps reeducation and strengthening.

Procedure:

- Magnetotherapy (11:30-11:50)
- Left hamstrings and quadriceps stretching by PFS technique.
- Patient in supine position: provides left extremity straight leg raise with hip ER, 2x10 repetitions.
- Patient in supine position: provides left extremity straight leg raise with hip IR, 2x10 repetitions.
- "Small foot" formation exercising.
- Sensomotoric exercises: half steps and lunges on rocker board and then on wobble board.
- Patient stands with his back on the wall and provides left hip F with small ER and knee E against Thera Band elastic resistance. 10 repetitions.
- Same exercises but patient is facing the wall and provides left hip E with small ER against elastic resistance. 2x10 repetitions.
- Patient stands with his back on Thera Band ball against the wall and slowly provides small squat. 2x5 repetitions.
- Patient stands with his left leg on blue Thera Band stability trainer and with his right leg provide hip F with knee E against Thera Band elastic resistance. 10 repetitions.
- Left hamstrings and quadriceps stretching by PFS technique.

Self therapy:

- Formation of "small foot".
- Left extremity straight leg raise with hip ER. Same exercise with hip IR.
- Small squating with his back on the wall.
- Hamstrings and quadriceps stretching.

7. Final kinesiologic examination

1) Posture evaluation:

a. Anterior view

- **Left foot in small pronation** (supplement 2, picture 2B).
- Out-toeing feet.

- **Left foot flat longitudinal and transverse arch, but less than at the initial examination** (supplement 2, picture 2B)**.**
- No knee valgosity/varosity.
- Right shoulder slightly depressed.
- Both hips in ER.
- Dominant hand: right
- Romberg tests (I,II,III): negative
- **Vele test: negative.**

b. Posterior view

- **Normal weight bearring** (supplement 1, picture 1B)**.**
- Heels and Achilles tendons symmetrical.
- Left thigh contour is thicker.
- Subgluteal lines symmetrical.
- Left trunk outline more concave.
- Both scapulas adducted.
- Right scapula lower.

c. Side view

- Head in slight anteflexion and protraction.
- Lower C-spine kyphotic
- Th-spine slight hyperkyphosis on upper part.
- L-lordosis flat.
- Pelvic posterior tilt.
- Knee joint position optimal.

2) Trendelemburg test:

Both extremities negative.

3) Gait evaluation:

- No trunk rotation.
- No arm synkinesis.

- Good control of speed and balance.
- Good stride and step length.
- Good pelvic movement.
- Provides slight ABD in right hip joint when walking.
- **Better heel contact and toe lift off. He does not put so much weight on the inside of his feet when walking. Also the lift off phase takes place more by his toes.**
- Backward walking: good.
- Tip-toe walking: good.
- Heel walking: good.

4) Active movement:

- Squat with both legs not painful.
- **Left leg squat not painful.**
- Left quadriceps isometric resistance: test was provided with the patient in sitting position, in 90/60/30 degrees of knee flexion. **Patient did not feel pain under any degrees of knee flexion.**
- Right quadriceps isometric resistance: not painful
- Hamstrings isometric resistance: both extremities not painful

5) ROM orientation examination by active movement:

a) Ankle joint

	Right extremity	Left extremity
PF	40°	40°
DF	10°	10°
Inversion	25°	25°
Eversion	15°	15°

b) Knee joint

	Right extremity	Left extremity
F	130°	120°
E	130° (return to zero	120° (return to zero

	position)	position)

c) Hip joint

	Right extremity	Left extremity
F with knee E	80°	**70° (better than at the initial examination but still a bit restricted)**
F with knee F	120°	**120°**
E	15°	15°
ABD	45°	45°
ADD	20°	20°
IR	25°	20°
ER	40°	40°

6) ROM orientation examination by passive movement:

a) Ankle joint

	Right extremity	Left extremity
PF	45°	45°
DF (with knee E)	15°	10°
Inversion	30°	25°
Eversion	20°	20°

b) Knee joint

	Right extremity	Left extremity
F	130°	120°
E	130° (return to zero position)	120° (return to zero position)

c) Hip joint

	Right extremity	Left extremity

F with knee E	85°	**80°**
F with knee F	120°	120°
E	15°	15°
ABD	45°	45°
ADD	25°	20°
IR	30°	20°
ER	40°	45°

7) Joint play examination (by Lewit) [20]:

	Right extremity	Left extremity
Calcaneous	Normal	Normal
Lisfrank joint	Normal	**Normal**
Talocrural joint	Normal	Normal
Knee joint	Normal	Restricted in dorsal direction
Patella	Normal	Restricted in caudal direction. Also crepitus.
Tibiofibular joint	Normal	**Normal**

- Sacroiliac joint: springing test normal, Patrick's phainomenon normal

8) Palpation:

- Iliac crests symmetrical.
- Anterior superior iliac spines symmetrical.
- Posterior superior iliac spines symmetrical.
- Left patella slightly glided laterally.
- **Left iliotibial band less stiff.**
- **Right triceps surrae normal tonus.**
- Both Achilles tendons look the same and feel the same in palpation.
- **Right Achilles tendon not painful on palpation.**
- Subcutaneous tissues and fascia mobility: both extremities normal.
- Passive extreme flexion of knee joint: both extremities not painful.
- Pressure of patella against knee: both extremities not painful.
- Medial and lateral borders of patella: both extremities not painful.

	Right extremity	Left extremity
Functional length	87cm	87cm
Anatomical length	95cm	95cm
Thigh circumference 15cm above patella	48cm	48cm
Knee circumference	37cm	37cm
2 scale measurement	44kg	41kg

Meniscus lession testing [6]:

- Apley test by compression: both extremities negative.
- McMurray test: both extremities negative.

Medial/lateral collateral ligament testing [6]:

- Apley test by traction: both extremities negative.

Cruciate ligament testing [6]:

- Lachman test (for anterior cruciate ligament): Both extremities negative.
- Posterior Drawer test (for posterior cruciate ligament): Both extremities negative.

9) Hypermobility tests:

- Thomayer distance: grade A hypomobility, (5cm no contact with floor).
- Sachse test for knee joint: both extremities grade B hypermobility (3cm)

10) Muscle length tests (by Janda) [16]:

- Triceps surrae: both extremities normal (0)
- **Hamstrings: left extremity limited (1), but less than at the initial examination.**
- Iliopsoas: both extremities normal (0)
- **Rectus femoris: both extremities normal** (0)
- Tensor fascia latae: both extremities normal (0)
- Sartorius: both extremities normal (0)
- Adductors: both extremities normal (0)

- Piriformis: both extremities normal (0)

11) Muscle strength tests (by Kendall):

- **Hip ER: left 5, right 5**
- Hip IR: left 5, right 5
- Hip ABD: left 5, right 5
- Quadriceps: left 5, right 5
- Gluteus medius: left 5, right 5
- Gluteus maximus: left 4+, right 5
- Triceps surrae: left 5, right 5
- Hamstrings: left 5, right 5

8. Therapy effect evaluation, prognosis

Contemplating the goals set at the beginning of the treatment, we would evaluate the therapy effect as very successful. Despite the limited number of therapy sessions, the patient had a rapid recovery, without disregarding of course that the treatment should be continued for a permanent long term effect.

Concerning the short term plan goals, with the most imortant being the decrease of pain, we observe that the patient does not experience any pain during everyday activities as well as when providing the formerly painful examination tests (table 2). At this point though, we should also mention the possible positive effect of the viscoelastic fusion in form of intraarticular injections that the patient had from the orthopaedic doctor (Erectus®), in the sequence described at the patient's anamnesis.

Flexibility of ITB together with hamstrings and rectus femoris muscle length have improved, despite the still small lack of normal left hamstrings length, along with ITB flexibility. Furthermore, restricted joints were mobilized successfully (table 2).

Very significant improvement was the decrease of the feet's pronation together with the increase of the feet's longitudinal and transverse arches (supplement 2, pictures 2A, 2B). Persistent work and exercise though is needed in order to further actively improve and possibly eliminate the particular defects. At this point, it should also be noted the possible use of in-shoe foot orthesis as a therapy proposal, for passive

improvement of these contributing factors, leading to passive changing of the load distribution on the talocrural, knee and the patellofemoral joints.

Another considerable improvement is the patient's weight bearing both during standing as well as when walking. Weight bearing is spread more symmetrical on the feet's plantar surface than at the beginning of treatment, with noticeable improvement at heel contact and toe lift off phase during gait (supplement 1, pictures 1A, 1B). From the above mentioned we can establish the determinant contribution of sensomotoric stimulation exercising (small foot formation, half steps and lunges on wobble board and rocker board) for diminution of foot pronation or foot arch malformation, when these are contributing factors in presentation of chondromalacia patellae.

Table 2: Summary of therapeutic effect changes.

	Results before therapy	**Results after therapy**
Posture, anterior view (see also supplement 2 pictures 2A, 2B)	Both feet in pronation. Both feet flat arches. Vele test positive.	Left foot in small pronation. Improved arch formation. Vele test negative.
Posture, posterior view (see also supplement 1 pictures 1A, 1B)	Weight bearing on inside of feet.	Normal weight bearing.
Gait evaluation	Bad heel contact and toe lift off.	Heel contact and toe lift off improvement.
Active movement	Left leg squat painful. Left quadriceps painful isometric contraction under resistance.	Left leg squat not painful. No pain in left quadricep isometric contraction under resistance.
Active ROM	Left hip F with knee E 60°. Left hip F with knee F 110°.	Left hip F with knee E 70°. Left hip F with knee F 120°.

Passive ROM	Left hip F with knee E 70°.	Left hip F with knee E 80°.
Joint play	Lisfrank and tibiofibular joints restricted.	Lisfrank and tibiofibular joint play normal.
Palpation	Left ITB stiff. Right Achilles painful. Right triceps surrae hypertonus	Left ITB less stiff. Right Achilles not painful. Right triceps surrae normal tonus.
Muscle length	Left hamstrings limited (1). Left rectus femoris limited (1).	Left hamstrings 1 but not as limited as before therapy. Left rectus femoris normal.
Muscle strength	Hip ER: right 4+, left 4+.	Hip ER: right 5, left 5.

Prognosis with chondromalacia patellae for this patient is very good. Despite the limited number of therapy sessions he had a significant immediate improvement. Continuation of a similar treatment program in the long term, can lead to elimination of chondromalacia patellae contributing factors and the patient's full functional level return.

Conclusion

Following a treatment plan like the one described in this Thesis, will have an immediate positive effect on patients with chondromalacia patellae. It should be noted though, the patient's perfect co-operation and motivation for hard work as a positive influence on the therapy outcome. The patient did not only exercise during treatment sessions but also provided the suggested self therapy exercises on every day basis.

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Supplement 1

Picture 1A: Weight bearing before therapy.

Picture 1B: Weight bearing after therapy.

Supplement 2

Picture 2A: Feet pronation and arch formation before therapy.

Picture 2B: Feet pronation and arch formation after therapy.

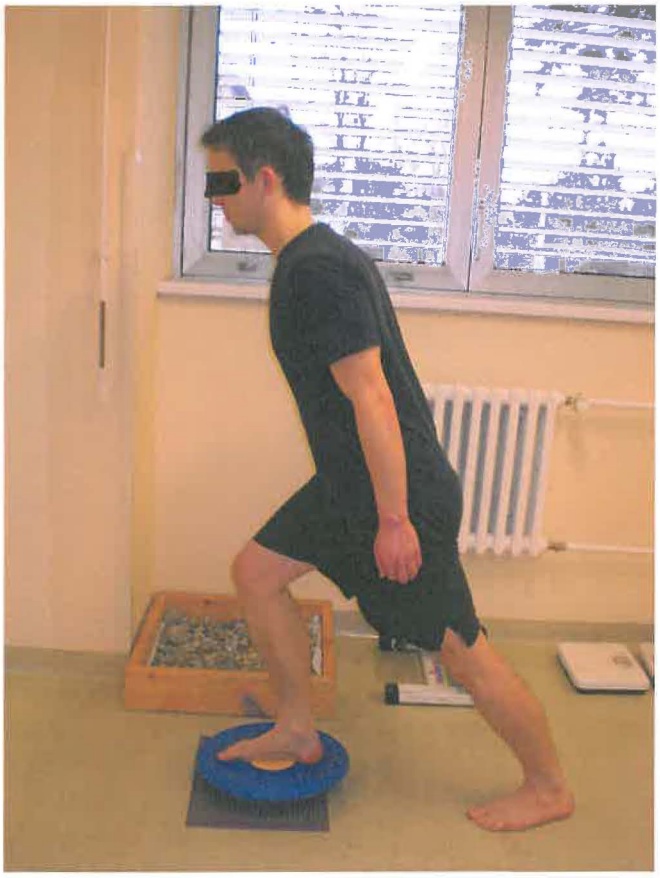
Supplement 3

Picture 3A: Exercising actively the formation of "small foot".

Picture 3B: Exercising actively the formation of "small foot".

Supplement 4

Picture 4: Straight leg raise exercising.



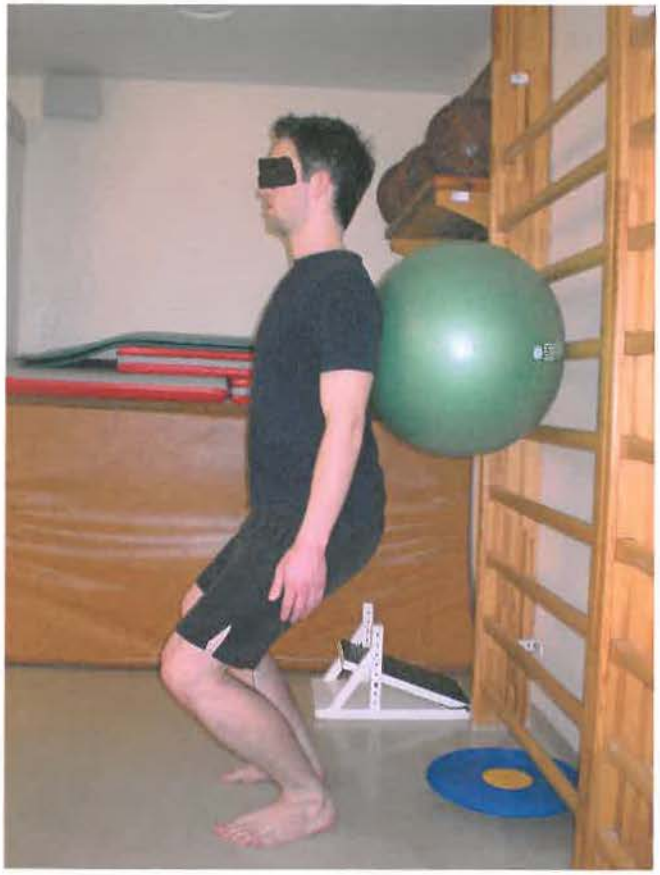
Picture 5: Performing lunges on wobble board.

Supplement 5

Picture 6: Exercising against elastic resistance: hip F in standing.

Picture 7: Exercising against elastic resistance on stability trainer.

Supplement 6



Picture 8: Squat exercising.

List of abbreviations

ABD: abduction

ACL: anterior cruciate ligament

ADD: adduction

AIIS: anterior inferior iliac spine

ASIS: anterior superior iliac spine

DF: dorsi flexion

E: extension

ER: external rotation

F: flexion

IR: internal rotation

ITB: iliotibial band

PCL: posterior cruciate ligament

PF: plantar flexion

PFJ: patellofemoral joint

PFJS: patellofemoral joint syndrome

PFPS: patellofemoral pain syndrome

PSS: pain severity scale

ROM: range of motion

TFL: tensor fascia latae

VL: vastus lateralis

VM: vastus medialis

VML: vastus medialis longus

VMO: vastus medialis oblique