Charles University

Faculty of Physical Education and Sports

A Case Study: Physiotherapeutic Treatment of a Patient with Post-Traumatic Fracture of the Tibial Plateau

Bachelor Thesis

April 2014, Prague

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Abstract

Title: A Case Study: Physiotherapeutic Treatment of a Patient with Post-Traumatic Fracture of the Tibial Plateau.

Title (Czech): Kazuistika Fyzioterapeutické Péče Pacienta s Posttraumatickou Zlomeninou Plata Tibie

Thesis Aim: This main aim in this case study is to investigate the efficacy of physiotherapeutic therapy performed on a 36 year old, female presenting with post-surgical indications for rehabilitation due to (Type IIIA) post- traumatic, compressive fracture of the left lateral tibial plateau.

Methods: The methodology employed within the practical part of this case study employs a wide array of physiotherapeutic approaches to restore knee function post- tibial fractures including: manipulative therapy, soft tissue techniques, isometrics, functional muscle release techniques, Proprioceptive neuromuscular rehabilitation, muscle stretch therapy and postural corrections. Ambulatory apparatus, exercising aids and equipment is utilized within the therapy. The patient's progress, with range of motion of the knee being the main marker, was measured at daily intervals with qualitative and quantitative clinical testing relevant to musculoskeletal rehabilitation. Specialized knowledge obtained from

Results: Implemented therapy resulted in improvement within the following parameters: muscle trophy, restoration of a physiological range of motion to the knee within the rehabilitative time frame, and functional stability of the knee. Finally, increasing the patient's independence in performing activities of daily living, and knowledge in auto-therapy execution.

Conclusion: Therapeutic approaches were successful in restoring range of motion of the knee to 120° flexion beyond the initial goal set for the duration of the therapy. The strength and muscle trophy of the lower extremity improved. Activation of the VMO has resulted in a stronger Quadriceps muscle contributing to stability of the knee joint

Keywords: Case study, Knee joint, Physiotherapy, Tibial Plateau, Tibial Fractures, Vastus Medialis Oblique, VMO

Declaration

I, Bettule Ali Hamed, hereby declare that the work enclosed within this dissertation is entirely my own. The information presented within this body of work is the culmination of my individual knowledge gained from everyday observation, practice and implementation at FTVS Charles University, accompanied by relevant research from accredited sources such as books, peer-reviewed journals, lectures, seminars and hospital internships.

From an ethical point of view, I would like to declare to all prospective readers that no invasive methods were used during the course of this patient's treatment and that the highest standards of patient safety were implemented.

Bettule A. Hamed,

April 2014, Prague

Acknowledgments

No scientific work put forth in this world was ever created in a vacuum. I owe the completion of this thesis, first and foremost, to all the professors that guided me in my course of study at the Faculty of Physical Education and Sports (**FTVS**) here in Prague. It is my true belief that your dedication and expertise will transform generations to come.

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To my family – from the youngest to the eldest– I thank you, words cannot do justice to all the support you have shown me.

To all FTVS alumni of class 2014, you have enriched my education tremendously, and for that I am grateful.

Finally, to the enigmatic city of Prague, its people, and its timeless beauty… a most perfect template for the contemplative mind, you have made this journey a truly unforgettable one.

Thank You,

Bettule Ali Hamed

April 2014, Prague

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1 INTRODUCTION

Fractures of the tibial bone comprise 1% of all fractures of the skeletal bones. The unique anatomical position of the tibia and its articulation with the femur give rise to the sophisticated knee joint complex. Injury of the knee obstructs ambulation, verticalisation and numerous other support functions to the musculoskeletal system.

This impairment is both a serious traumatic injury and a socioeconomic concern for the affected group of individuals, whether young or old. This fracture can easily result from high and low velocity accidents, making daily activities such as crossing the street or engaging in sports a potential factor in injury.

In sports traumatology, the knee is the most commonly injured part of the athlete or amateur enthusiast pursuing outdoor activities. Therefore, the relevance of this study extends far beyond what appears as the focal subject of fractures.

The aim of this thesis is to highlight effective rehabilitative process for patients with fracture of the lateral tibial plateau. By monitoring recovery of an individual patient, this endeavor is in essence, an investigative case study from a physiotherapeutic perspective as to the most effective approaches to treatment.

A general overview is covered at the beginning of this thesis in order to highlight the theoretical knowledge that will have a bearing on the practical procedures carried out in the specialized section.

2 GENERAL PART

2.1. Anatomical Review

In this segment of the study a regional, anatomical overview of the knee will be covered for referential purposes. Any practitioner attempting to rehabilitate trauma to the knee joint complex must be aware of the intricacies of this structure.

2.1.1. The Knee Joint

The Knee joint is a complex bicondylar hinge joint. It is the largest synovial joint in the human body located midway in the lower limb (30). It allows flexion and extension in the sagittal plane although, other movements such as gliding and rolling with rotation about a vertical axis also occur but are very miniscule and generally limited by the knee's ligamentous and muscular framework, making it one of the most stable joints in the human body (21) However, due to its complex structure and anatomical, it is often the site of many traumatic injuries.

2.1.2. Articulation of the Knee

The knee's articulation is formed between the following bones: the distal end of femur, proximal end of tibia, and posterior surface of the patella (26). It is of anatomical significance to mention that the fibula is not involved in the knee joint. It forms a separate, rigid articulation with the tibia called the *tibiofibular joint*.

Figure 1. Bones comprising articular surfaces of the knee (23)

The articular surfaces of the knee joint are characterized by their large size, sophisticated and incongruent shapes. Three articulations are found in the knee joint. The femur and tibia form the *femorotibial joint* (lateral and medial between the two condyles), while the femur and patella form the *patellofemoral joint (16).*

The stability of this joint is provided by the actions of surrounding muscles, meniscii, ligaments connecting the tibia and femur. Anatomy of these structures are reviewed in the sections below.

2.1.3. Ligaments

The joint capsule is fortified by many ligaments. The major extracapsular ligaments are the *patellar ligament* comprising the distal part of the quadriceps tendon, a strong fibrous band passing over the patella (knee cap) and inserting into the tibial tuberosity (26).

Two large ligaments run on either side of the knee. The tibial collateral ligament also called the *medial collateral ligament* (MCL), is a strong flat band extending from the medial epicondyle of the femur to the superior, medial condyle of the tibia (11). The second is the fibular collateral ligament also known as the *lateral collateral ligament* (LCL) extending from the lateral epicondyle of the femur to the head of the fibula. The direction of the collateral ligaments is such that they tighten during extension and contribute to 'locking' mechanism of the knee. They also provide medio-lateral stability.

The intra-articular ligaments are called the *cruciate ligaments*; there are two criss-crossing each other in the form of an X. The *anterior cruciate ligament* (ACL) is the weaker of the two. It passes from the anterior intercondylar area of the tibia extending superiorly, posteriorly and laterally attaching to the lateral condyle of the femur. The ACL prevents the anterior displacement of the tibia along the femur (8).

The *posterior cruciate ligament* (PCL), the stronger of the two ligaments, arises from the posterior intercondylar area of the tibia passing superiorly and anteriorly, crisscrossing the ACL on its way to attach to the medial condyle of the femur (8). The PCL prevents the posterior displacement of the tibia with respect to the femur.

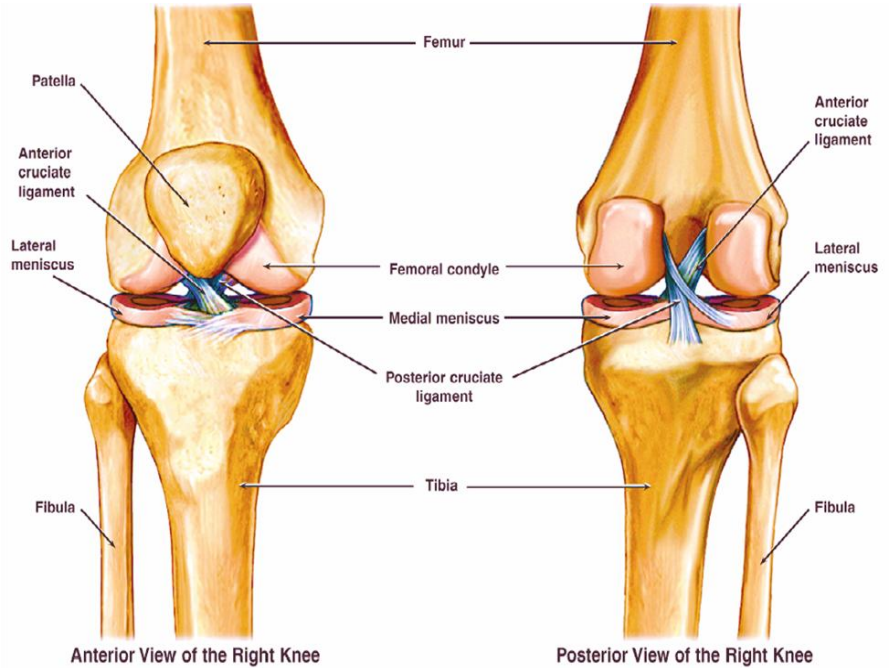

Figure 2. Anterior and posterior view of the major ligaments of the knee (23).

2.1.4. Meniscii

The meniscii of the knee are found within the joint capsule as C-shaped plates of fibrocartilage on the articular surface of the tibia. They are interposed between the femoral and tibial condyles**.** They deepen the tibial surfaces acting as shock absorbers for the knee during impact (12). The *medial meniscus* is lunar shaped and broader posteriorly than anteriorly, it lies on the inside of the knee joint. On the other hand the *lateral meniscus* is

nearly a circular ring laying inside the lateral part of the knee. The presence of the knee meniscii improves weight bearing on the lower half of the lower limb.

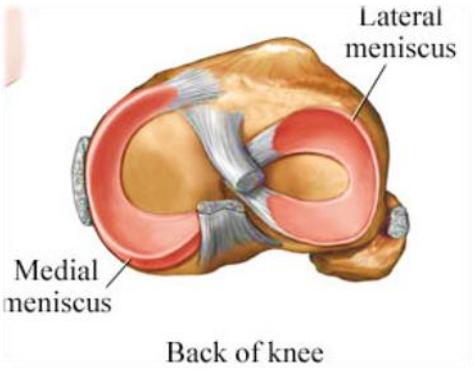

Figure 3. Superior view of the knee meniscii (23).

2.1.5. Muscles that move the Knee

Muscles that mobilize the knee originate either in the hip or thigh. The knee performs two main movements: extension and flexion, we can expect two groups of muscles acting on the knee joint: the knee flexors group and knee extensors group. The muscles around the knee are very crucial in providing stability for the joint.

Movement	Target	Target motion direction	Prime mover	Origin	Insertion
Medial compartment of thigh					
Moves back of lower legs up toward buttocks, as when kneeling; assists in opening thighs	Femur; tibia/fibula	Tibia/fibula: flexion; thigh: adduction	Gracilis	Inferior ramus; body of pubis; ischial ramus	Medial surface of tibia
Anterior compartment of thigh: Quadriceps femoris group					
Moves lower leg out in front of body, as when kicking; assists in raising the knee	Femur; tibia/fibula	Tibia/fibula: extension; thigh: flexion	Rectus femoris	Anterior inferior iliac spine; superior margin of acetabulum	Patella; tibial tuberosity
Moves lower leg out in front of body, as when kicking	Tibia/fibula	Extension	Vastus lateralis	Greater trochanter; intertrochanteric line; linea aspera	Patella; tibial tuberosity
Moves lower leg out in front of body, as when kicking	Tibia/fibula	Extension	Vastus medialis	Linea aspera; intertrochanteric line	Patella; tibial tuberosity
Moves lower leg out in front of body, as when kicking	Tibia/fibula	Extension	Vastus intermedius	Proximal femur shaft	Patella; tibial tuberosity
Moves back of lower legs up and back toward the buttocks, as when kneeling; assists in moving thigh diagonally upward and outward as when mounting a bike	Femur; tibia/fibula	Tibia: flexion; thigh: flexion, abduction, lateral rotation	Sartorius	Anterior superior iliac spine	Medial aspect of proximal tibia
Posterior compartment of thigh: Hamstring group					
Moves back of lower legs up and back toward the buttocks, as when kneeling; moves thigh down and back; twists the thigh (and lower leg) outward	Femur; tibia/fibula	Tibia/fibula: flexion; thigh: extension, lateral rotation	Biceps femoris	Ischial tuberosity; linea aspera; distal femur	Head of fibula; lateral condyle of tibia
Moves back of lower legs up toward buttocks, as when kneeling; moves thigh down and back; twists the thigh (and lower leg) inward	Femur; tibia/fibula	Tibia/fibula: flexion; thigh: extension, medial rotation	Semitendinosus	Ischial tuberosity	Upper tibial shaft
Moves back of lower legs up and back toward the buttocks as when kneeling; moves thigh down and back; twists the thigh (and lower leg) inward	Femur; tibia/fibula	Tibia/fibula: flexion; thigh: extension, medial rotation	Semi-membranosus	Ischial tuberosity	Medial condyle of tibia; lateral condyle of femur

Figure 4. Tabular representation of muscles that move the femur, tibia, and fibula (24).

2.1.6. Nervous Innervation

The nerves of the knee are branches from the femoral, tibial, and common fibular nerves. The muscles that perform flexion and extension of the knee are innervated by the femoral and sciatic nerve (16). Lacerations to these two major nerves will impair mobility of the knee and sensation to the lower limb.

The remaining nerves go around the knee or inferiorly along the popliteal fossa (16). The popliteal nerve on the backside of the knee has large tracts innervating the lower leg and foot. The popliteal nerve branches just above the knee to form the tibial and peroneal nerve, the tibial nerve continues on the posterior part of the lower leg while the peroneal nerve travels around and down the front of the leg ascending to the foot. Fractures of bones forming the knee joint pose a risk of injury to these nerves impairing motion and sensation of the lower leg.

2.2. Kinesiology of the Knee Joint

The curvatures of the articular surfaces of the knee are such that hinge movements are combined with gliding, rolling, and rotation about a vertical axis (13). Flexion of the thigh at the knee is first accompanied by lateral rotation of the thigh, and the femur then rolls posterior-forward on the tibia. Conversely, the last part of extension is accompanied by medial rotation of the thigh, and the collateral ligaments are then taut and the joint is most stable.

The quadriceps femoris extends the leg, and the hamstrings flex it. The biceps rotates the leg laterally, and the semitendinosus rotates it medially (13). The popliteus muscle, acting from a fixed tibia, is believed to be significant in rotating the femur laterally.

The range of flexion depends on position of the hip and whether movement is *active* or *passive*. Usually, some passive movement of the tibia beyond alignment of the long axes of the thigh and leg (hyperextension). Flexion of the knee is normally limited by contact with the calf muscles; however if the movement ends sooner it indicates a retraction of quadriceps or shortening of capsular ligaments (13). Males usually have a lower range of

flexion than females due to a larger calf circumference. Normal range of motion, is between 120° and 150°.

In extension, the knee passively locks because of the medial rotation of the femur on the tibia. This position turns the lower limb into a rigid column suitable for weight-bearing. Whereas at the beginning of flexion, the femur rotates laterally on the tibia and unlocks the knee enabling the lower limb to enter the swing phase of gait.

2.2.1. Biomechanics of the Tibiofemoral Joint

The primary impacted anatomical structure in this case study is that of the lateral tibial plateau. Fracture of this site will closely affect many secondary, synergistic structures most notably the tibiofemoral articulation. Dysfunction in this articulation will give rise to limitations in the both extension and flexion.

During Arthrokinematics of closed chain knee flexion / extension the convex femoral condyles move on concave tibial condyles; therefore distal and proximal segments are moving in opposite directions (6). During extension the tibia glides anteriorly on the femur if this glide is prolonged the last 20° of motion will initiate the “home screw mechanism”, locking the knee. During, flexion involves a combination of rolling and gliding of the femoral condyles on the tibial condyles. The femur rolls posterior and glides anterior to the tibia. For the femur to continue to roll on the tibia without “falling out” of the tibial plateau it must simultaneously glide forward (6). Please refer to the figure 4.0 for a schematic representation of rolling and gliding of the femur.

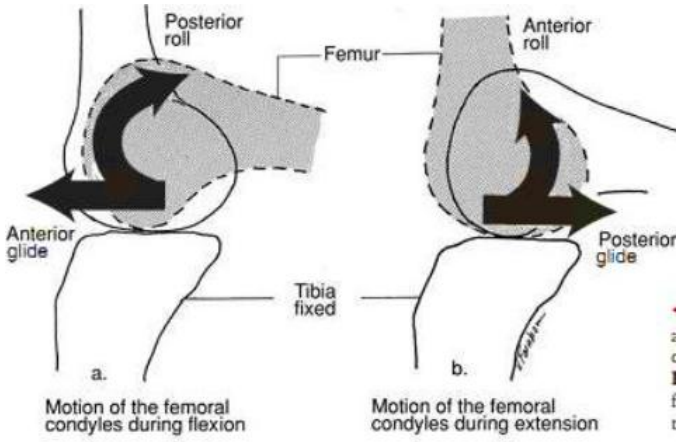

Figure 5. Arthrokinematics of tibiofemoral joint (6).

2.3. Characteristics of the Tibia Bone

The Tibia also known as the shinbone, is a large weight-bearing bone located in the lower leg. It is the second longest bone after the femur of the thigh. The tibia is the inner and thicker of the two long bones in the lower leg. It is prismoid in form, larger above (23), where it enters into the knee-joint, smaller in the lower third, and again enlarged but to a lesser extent below.

In the male, its direction is vertical, and parallel with the bone of the opposite side; but in the female it has a slightly oblique direction downward and lateral-ward (23), to compensate for the greater obliquity of the femur (the Q angle).

Proximal Tibia:

At the proximal end, the tibia is widened by the medial and lateral condyles, aiding in weight bearing. The condyles form a flat surface, known as the **tibial plateau**. This structure articulates with the femoral condyles to form the major articulation of the knee joint.

On the anterior surface of the proximal tibia, inferior to the condyles, the tibial tuberosity is situated. This is where the patella ligament attaches

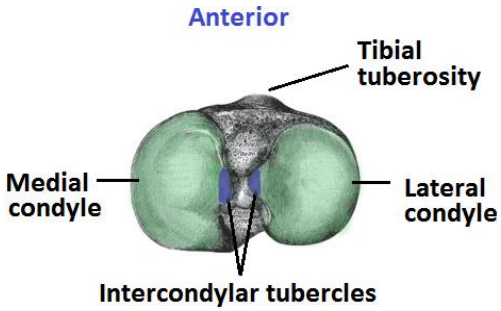

Figure 6. The tibial plateau and tibial condyles articulates with the femoral condyles to for majority of the knee (23).

Shaft of Tibia:

The shaft of the tibia has three borders and three surfaces; anterior, posterior and lateral. For brevity, only the anatomically and clinically important borders/surfaces are mentioned below.

Anterior border - The start of the anterior border is marked by the tibial tuberosity. It is palpable down the anterior surface of the leg as the shin (28). Here, the periosteal covering of the tibia is susceptible to damage, presenting clinically as bruising.

Posterior surface - This is marked by a ridge of bone called the soleal line (27). It runs inferomedially, eventually blending with the medial border of the tibia. It is here where part of the soleus muscle originates

Lateral border - Also known as the interosseous border. This gives attachment to the membrane that rigidly binds the tibia and the fibula together.

Distal border - The distal end of the tibia, like the proximal, widens to help with weight bearing. There is a bony projection continuing inferiorly on the medial side called the medial malleolus. It articulates with the tarsal bones to form part of the ankle joint (27). On the posterior surface of the tibia, there is a groove where the tibialis anterior muscle attaches.

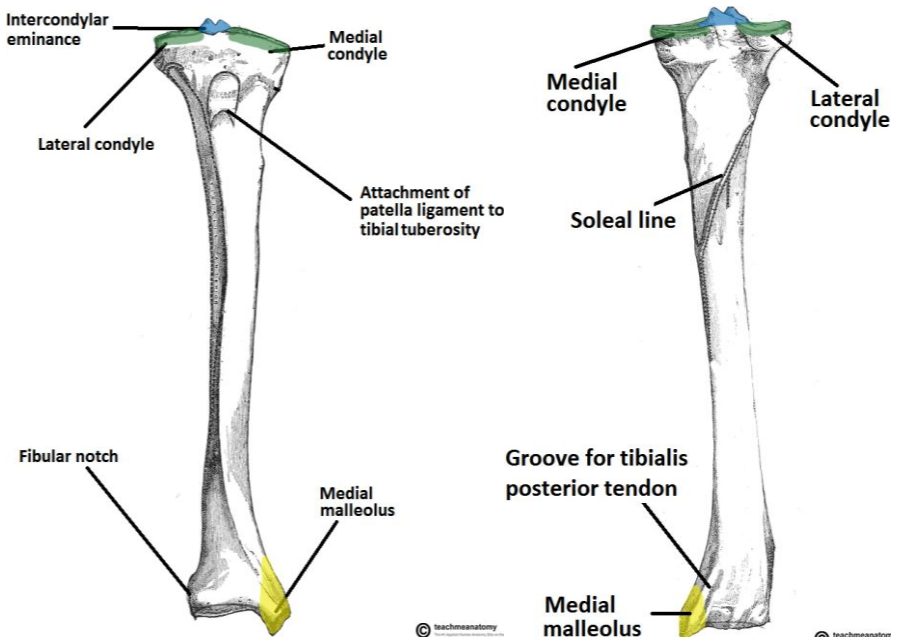

Figure 7. Anterior surface of the tibia (left) and posterior surface of tibia (right) (26).

2.3.1. Ossification of the Tibia

The tibia is ossified from *three* centers (figure. 5): one for the body and one for either extremity. Ossification begins in the center of the body, about the seventh week of fetal life, and gradually extends toward the extremities (10). The center for the upper epiphysis appears before or shortly after birth; it is flattened in form, and has a thin tongue-shaped process in front, which forms the tuberosity. That for the lower epiphysis appears in the second year. The lower epiphysis joins the body at about the eighteenth, and the upper one joins about the twentieth year. Two additional centers occasionally exist, one for the tongue-shaped process of the upper epiphysis, which forms the tuberosity, and one for the medial malleolus (9).

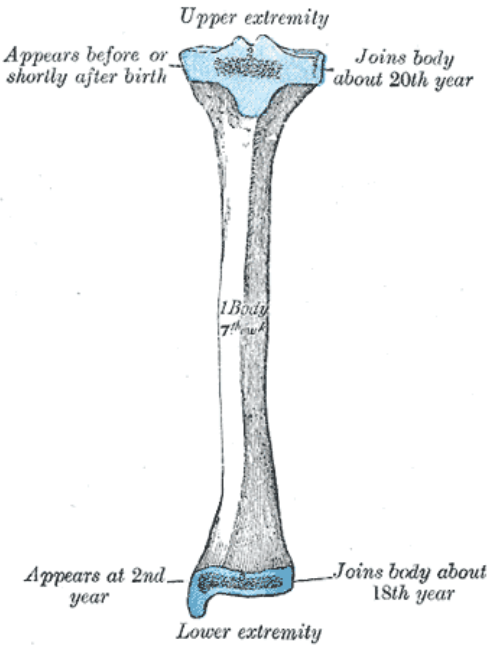

Figure 8. Ossification plan of the tibia from 3 origin centers.

2.3.1. Mechanisms of Injury

When presented with patients sustaining traumatic injuries, it is extremely invaluable to the physiotherapist to learn the *mechanism* of injury. Understanding the dynamics by which an injury occurred can provide valuable clues as to which structures sustained "unseen" trauma so to speak, for those have to be rehabilitated as well.

Mechanisms of injury that fractures the tibia can be divided into two categories (17):

1. Low- energy traumas such as ground levels falls and athletic injuries
2. High- energy traumas such as motor vehicle injuries, pedestrians struck by motor vehicles, and gunshot wounds.

Strong forces directed medially or laterally at the knee joint, combined with axial loading, causes the majority of proximal tibial plateau fractures. Automobile accidents account for 40% to 60% of all tibial plateau fractures. Other mechanisms include falls from heights, slipping and twisting, sport injuries and motorcycle and biking injuries. About 15% - 45% of fractures include a ligamentous rupture, commonly of the MCL or LCL. Meniscal lesions occurs in almost 20% of all cases.

The patient in this study presents with a typical mechanism of injury to the tibia called the "*boot top fracture*" seen in skiing athletes (17). A high rotational load is place on the lower leg, resulting in a spiral fracture to areas of the proximal tibia, when combined with an impactful fall, there can be an additional compressive fracture presenting in the tibia.

2.3.1. Epidemiology and Incidence Rate

The incidence of tibial fractures accounts for 1% of all skeletal fractures (14). According to a 7-year long study on a sample of 513 patients reveal the highest frequency occurring in the 20 - 30 year old age group in both genders, with women having a higher incidence rate than men in people aged > or =50 years old. The reason for this high incidence in the female population, according to Riggs (1995), may be due to osteoporosis being prevalent among the female demographic making long bones particularly susceptible. Females with osteoporosis may have a seemingly innocent mechanism of injury and *still* sustain severe tibial fracture. The most common cause of fractures was road traffic accidents; 54% of all injuries were closed fractures and 46% were open. The most frequent fracture pattern was the comminuted one in which the tibia fractures into three or more pieces (20). Generally, Tibial plateau fractures occur in young patients involved in high velocity injuries or in the elderly and osteoporotic population with low energy forces.

2.3.2. Classification of Tibial Fractures

A tibial plateau fracture involves the proximal 10-12cm of the tibia. The lateral tibial plateau is fractured more frequently than the medial plateau (27), as is in the case of the patient treated in this study.

Numerous classifications of tibial plateau fractures have been introduced over the years. The Schatzker classification system for tibial plateau fractures is used widely by orthopedic

surgeons to assess the initial injury, plan management, and predict prognosis (19) and for this reason it is described in this case study. The Schatzker classification divides tibial plateau fractures into *six types*:

1. Lateral plateau fracture without depression (**type I**),
2. Lateral plateau fracture with depression (**type II**),
3. Compression fracture of the lateral (type IIIA) or central (Type IIIB) plateau,
4. medial plateau fracture (**type IV**),
5. bicondylar plateau fracture (**type V**)
6. Plateau fracture with diaphyseal discontinuity (**type VI**).
7.

The following figures taken from Mostofi (2006) represent the fracture site within the tibial plateau according to the Schatzker classification system.

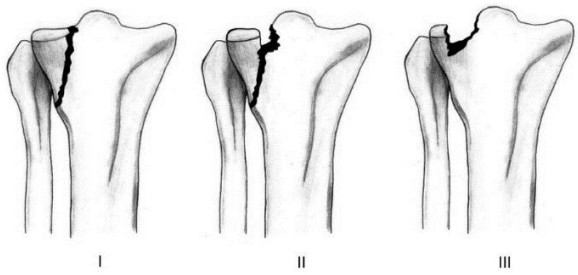

Figure 9. Classes I, II, III of tibial plateau fractures according to Schatzker (22).

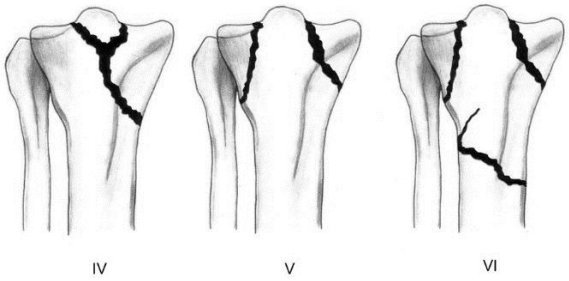

Figure 10. Classes IV, V, & VI of tibial plateau fractures according to Schatzker (22).

Management of type I, II, and III fractures centers on evaluating and repairing the articular cartilage (19). The fracture-dislocation mechanism of type IV fractures increases the likelihood of injury to the peroneal nerve or popliteal vessels. In type V and VI fractures, the location of soft-tissue injury dictates the surgical approach and the degree of soft-tissue swelling dictates the timing of definitive surgery and the need for provisional stabilization with an external fixator. CT and MR imaging are more accurate than plain radiography for Schatzker classification of tibial plateau fractures.

Given the six types of fracture, In general fractures may be deemed stable or unstable. Fractures to the tibia *are often* broken to more than one piece resulting in bone displacement, and this makes them highly unstable. Even if they only sustain a crack or breakage without muscles pulling in the leg – the tibial tuberosity (located) near the plateau is the site of insertion of large muscles. Muscular activity around the fracture site can pull at the individual bone fragments causing the tibia to be highly unstable (23). Such fractures require immediate internal fixation through surgical intervention as opposed to conservative management.

2.3.3. Diagnostic Imaging

From a clinical standpoint it can be easily attested that diagnostic imaging will help the therapist, alongside manual testing, to reach the most comprehensive diagnosis (5). The clinical presentation of bone injuries frequently mimics the other musculoskeletal problems; therefore laboratory testing and imaging can expedite the diagnostic process (3). Tibial plateau fractures are usually revealed with anteroposterior and lateral radiographs of the knee. Computed Tomography scans and MRI imaging are more accurate than plain radiography for Schatzker classification of tibial plateau fractures (3). CT scans usually produce excellent images from which to assess depressions and displacements.

2.4. Clinical Examination.

The typical patient with a tibial plateau fracture presents symptoms of moderate and sever pain in the knee. Upon inspection, the knee can be seen visually as swollen with the most severe injuries at risk of compartment syndrome (2). Most patients will be unable to weight-bear secondary or ambulate due to knee instability and pain 17)

When examining a patient for a lower leg fracture one should first examine the patient for edema, ecchymosis, and point tenderness, cyanosis, and cool skin at the end of the extremity. Upon identifying these symptoms, complete physical examination of the knee is warranted.

Tibial plateau fractures with knee effusions often present with tenderness along the medial or lateral tibial plateau, approximately 3cm below the plateau along the tibial ridge. Tibial fractures rarely occur in isolation. Knee structures are commonly damaged in conjunction with tibial fractures. Approximately 20% of tibial plateau fractures are associated with ligamentous injuries to the knee (28).

Comprehensive orthopedic testing of the ligaments of the knee must be performed. This includes the following evidence- based specialized test (28):

Of crucial importance is the Lachman test consistent with confirming ACL tearing. This test is the best indicator of injury to the anterior cruciate ligament, especially the posterolateral band (14). Therapist holds the patients knee between full extension and 30 degrees of flexion while the patient's femur is stabilized with one of the examiner's hands (outer hand) while the proximal aspect of the tibia is moved forward with the other hand.

According to Magee (2009) Injury to the meniscii can be assessed with the Mcmurry test, the Patient lays in the supine position with knee completely flexed. The examiner then medially rotates the tibia and extends the knee. If there is a loose fragment of the lateral meniscus, this action causes a snap or click that is often accompanied by pain. To test the medial meniscus, the examiner performs the same procedure with the knee laterally rotated.

Other tests such as the medial stability test to assess for laxity or tears in the collateral ligaments and the posterior drawer test can be performed too in the fibula is intact (14).

A careful neurovascular assessment should be performed. The peroneal nerve is at risk of injury during tibial plateau fractures (17). A special test for this is “Tinell’s sign” for peroneal nerve irritation at the fibular head.

2.4.1. Surgical and Post-surgical Complications

In many tibial plateau fractures, conservative treatment is not an option due to the fracture’s highly unstable nature. In the case of surgical intervention, the main goals are to reconstruct the articular surface and re-establish tibial alignment. Surgical complications include: mal-alignment, or the inability to correctly position the broken fragments, risk of infection, sharp bone fragments may cut or tear adjacent muscles, nerves, or blood vessels (4).

Patients who recover from surgical interventions of tibial plateau fractures experience edema, pain, loss of ROM, strength and function in the lower limb, all of which are indications for physical therapy.

Knee stiffness is perhaps the most common complication seen after tibial plateau fractures (7). Although immobilizing the knee is acceptable while bridging a tibial plateau fracture with an external fixator or while waiting for soft-tissue flaps to heal, in most cases, the knee will suffer marked stiffness.

Both operative and non-operatively treated fractures are at an increased risk of developing secondary osteoarthritis at the site of the osteochondral lesion (18). In the long run, genu valgum may develop following depression of the lateral tibial condyle.

2.5 Tibial Plateau Fracture: physiotherapeutic guidelines

In planning treatment, therapists must consider the cause of the injury, patient’s age and overall health, the severity of the injury, the extent of soft tissue damage and the secondary muscular deficiencies.

Length of time to return to daily activities varies with different types of plateau fractures. Some tibial plateau fractures heal within 4 months, yet many may take 6 months or longer to heal (9). This is particularly true with open fractures and fractures in patients who are less healthy.

Early range of motion (ROM) of the knee and the maintenance of non-weight bearing (NWB) on the affected leg is considered critical during recovery. Prolonged immobilization in a cast has been found to increase stiffness that is not amenable to physical therapy, therefore this must be avoided early on in the treatment. In general, **the goal should be to gain 90° flexion ROM by 6 weeks post operatively.**

Goals must be individualized to the patient within established time frames. Therapy typically hinges on decreasing pain and edema. Without improvement in the latter two parameters the patient will be highly ambivalent in engaging in any kind of exercise. Increasing global strength in the lower extremity, ensuring the patient is independent in transfers, short distance ambulation and ascending stairs while maintaining NWB.

The patient plays a role in his/her recovery as well. We must ensure the patient understands precautions and NWB status (27). Ensuring the patient is armed with necessary pointers for self-management of symptoms. Since engagement in therapy must be continuous the physiotherapist must ensure that the patient is independent in their initial home exercise program.

Presented below are critical parameters to be assessed and rehabilitated:

Edema: the therapist performs circumferential measurements of the knee joint, calf and thigh as appropriate. Apply cold therapy to any swelling.

ROM: assess active (AROM) and passive range of motion (PROM) of the knee joint, using goniometry. Also assess the ankle and hip joint motion (10). Assess uninvolved extremities to the extent needed, as the patient will likely need to use an assistive device to function in NWB.

Strength: use Manual Muscle Testing (MMT) muscles of the knee as appropriate. *The therapist should avoid any tests that unnecessarily stress the fracture.*

Balance: assess the patient's ability to maintain balance with NWB using an assistive device. Assess balance on the involved leg as appropriate when the fracture is healed and weight-bearing status is progressed.

2.5.1 Recovery of the Knee Following Tibial Plateau Fracture

When treating intra-articular fractures, the goal is to obtain a stable joint permitting early range of motion (9), in the case of tibial plateau fracture, physiotherapy must focus on the knee.

According to a study made by Gaston (2005), the functional outcome of the knee following fracture of the tibial plateau in 63 patients was studied. Measurements of joint movement and muscle function were made using a muscle dynamometer at 3, 6 and 12 month intervals following injury. Thirteen patients (21%) had a residual flexion contracture at one year. Only nine (14%) patients achieved normal quadriceps muscle strength at 12 months, while 19 (30%) achieved normal hamstring muscle strength. Recovery was significantly slower in patients older than 40 years of age.

As physiotherapists we conclude that there is significant impairment of movement and muscle function after fracture of the tibial plateau and that the majority of patients have not fully recovered even after one year from injury date. The fact that only 14% of patients achieved normal quadriceps function is both alarming and indicative of the need to focus on strengthening this key muscle, a prime mover and stabilizer of the knee.

Scientific literature reveals within the following studies Manidakis (2010), Willis (2013), and Kushion (2008) that isometric hamstring exercises and isometric exercises of the quadriceps followed by isotonics are an integral part of rehabilitating the knee. Any technique that facilitates the knee extensors and flexors must be utilized in the therapy. Preferential activation of the Vastus Medialis Oblique of the quadriceps muscle has been shown to have the greatest effect on knee stability. Strengthening the VMO reduces strain on the patellofemoral and tibiofemoral articulations of the knee during motion.

2.6 Prognosis

Tibial plateau fractures requiring surgery are severe injuries. For professionals, amateurs, and recreational athletes, tibial plateau fractures might affect leisure and professional life. A return to activity depends on the patient's fitness level and lifestyle prior to surgery. Age is another factor in the recovery process with the younger population having better prospects. But perhaps the most important factor, is the degree of traumatic damage (1). *Complex* tibial plateau fractures are associated with nonunion and malunion, as a result of comminution, unstable fixation, failure to bone graft, infection or combination of these factors. Generally patients in this category have a poor prognosis marked by slow recovery. Overall the prognosis is good for with the worst prognostic determinant being tibial infections (1).

3 SPECIAL PART

3.1. Methods

Research and evaluation of this case study took place in Centrum Léčby Pohybového Aparátu Vysočany (C.L.P.A.), in Prague for the duration of 10 days between 06.01.2014 to 20.01.2014. The total hours of practice is 80 hours.

The clinic specializes in rehabilitation post orthopedic surgery and sports traumatology. The center offers a wide range of therapeutic techniques and modalities, including electrotherapy, hydrotherapy and a fully equipped fitness room, making it a unique environment to utilize for this case study. The rehabilitation clinic is conjoined to an in-patient orthopedic surgery unit.

My Patient presented with Post-lateral tibial plateau fracture. She underwent orthopaedic surgery – procedure: arthroscopically assisted percutaneous osteosynthesis (AAPO) – at a separate hospital and pursued physiotherapy treatment here. An initial kinesiological examination was conducted at the beginning of the practice followed by six therapy sessions, including a final kinesiological examination to evaluate the results. The aim of our study was to evaluate the results of lateral tibial plateau fractures treated with an individualized physiotherapy plan.

Research was conducted by gathering objective and subjective physiotherapeutic data that can be both *measured* and *sensed* through inspection, palpation and observation. A number of physiological, neurological and orthopaedic special tests are used to examine the patient's musculoskeletal state and to track progress.

Therapeutic approaches employed in the rehabilitation program of this case study involved approaches from soft tissue techniques, exercise physiology, manipulative therapy, and PNF techniques combined with unique insights the Prague school of physiotherapy; its steeped knowledge and history in the sciences of rehabilitation. The goals as well as the details of the rehabilitation plan will be outlined below.

My practice was supervised by Mgr. El Ali Zaher, a practicing physiotherapist. All examinations and therapy provided to patient was implemented in cooperation with him and in accordance with the highest standard of patient care.

The patient participated in this case study out of her own volition; she gave her informed consent enclosed at the end of this work. Please view ***supplement in section 6.4***. The Committee of the Ethics Review Board at Charles University in Prague, Faculty of Physical Education and Sports has approved this research endeavor. The approval number ***supplement can be viewed in section 6.5.***

3.2. Anamnesis

Performed on 06.01.14.

Patient being examined: M.H. **Year:** 1978.

Sex: Female

Diagnosis: T 932 Fracture of left lateral tibia

Chief Complaint: post-operative flexion restriction and stiffness of the knee joint

Present State.

The patient's present condition is reported as anxiety and pain-free. Patient reports minor back and neck aches at night-time due to the limitation of sleeping on her back. This is to avoid pressure on anterior aspect of the tibia. On a scale of 0 to 10 with 0 being no pain in the area of injury, and 10 being maximal pain; patient states pain-sensation as (0). Patient is on her 23rd post-operative day, approximately 3 weeks since AAPO surgery on December 14th, 2013.

Body anthropometrics.

- Height: 178cm - BMI: 17.04 kg/m$_2$ - Weight: 54kg
- Dominance: right - Somatotype: ectomorph

Current vitals.

- Resting HR: 79 bpm - sitting BP: 118/73mmHg - temperature: 37.4°C

A BMI of 17.04 is considered underweight for adult females aged > 18 years. Patient's cardiac parameters at the time of examination are physiological with a resting heart rate of 79 BPM and blood pressure of 118/73 mmHg. Her body temperature is a physiological 37.4 °C. The patient reports heart palpitations when ascending stairs and a slight dizziness.

Aids.

Patient is currently walking with the aid of underarm crutches. Also, an orthotic Knee brace is worn for fixation during walking, standing or anytime the patient is in mobile activity.

History of the present problem.

Patient is an avid skier. She been skiing since the age of 9 years old. On December 13th, 2013, according to M.H.'s testimony, she was skiing down a steep slope that was particularly icy and proceeded to veer of coarse causing an impactful fall. The following description reveals *the mechanism of the injury*: the right ski slipped and the right leg was flung outwards, the patient was out of balance and the *left leg* bore the compressive forces as she tumbled and fell, additionally the ski boot restriction caused shear forces and pain to the proximal tibia resulting in a compressive fracture to the lateral tibial plateau. Coincidently, the left Fibula is unharmed and remains intact. Also, all four of the knee ligaments are intact (ACL, PCL, MCL, LCL).

Surgery was indicated immediately for the following day, On December 14th, 2013 arthroscopically assisted percutaneous osteosynthesis (**AAPO**) of the tibial plateau was successfully performed on M.H.

Family history.

Father passed away from Pancreatic Cancer, mother complains of low back pain for majority of her adult years.

Past medical history.

Patient suffered from all common childhood diseases including the Chicken Pox. She suffered from acquired Anemia for 1 year at the age of 8 years old and was treated with iron supplements successfully overcoming it. Patient she has a normal menstrual cycle and has been using the oral contraceptive pill since the age of 17 years old.

In May 2010, she experienced the onset of low back pain. Upon visiting a medical practitioner, no disc pathologies were found, and only cortisol injections were prescribed for pain relief. At the time, she visited a physiotherapist where back strengthening exercises

were carried out, particularly Mackenzie exercises. Patient is now free of low back pain and the problem has subsided.

Surgical history.

In April 1996 she had Anterior Cruciate Ligament (ACL) repair surgery performed on her right knee. Recovery post-surgery was very slow and took upwards of 6 months. In December 2013 she had arthroscopically assisted percutaneous osteosynthesis (AAPO) performed to repair her left fractured tibial plateau.

Pharmacological history.

Levenorgestral and Ethinyl Estradiol - *Oral Contraceptives*.

Ferrous Fumarate - *Iron supplements*.

Calcium Carbonate - *Calcium supplements*.

Ginko Biloba – *natural, herbal vasodilator and psycho-stimulan*t.

Korylan – *pain and fever medication*.

Cortisol – *taken in the form of intra-venous infusions*.

Psychosocial history.

M.H. lives with her common-law partner, who travels for business frequently so she resides independently during these periods and must perform house chores alone; a cleaning lady visits 2x/ week. The couple have no children. Their place of living is on the third floor with access to an elevator. The residential environment does not present any challenges to the patient with her current condition. Overall, the patient is very engaged in her life both mentally and actively and describes her outlook as optimistic and positive. Her current condition is not preventing her from working. From an activity standpoint, she feels a deep

longing to return to swimming and gym training which she used to perform on a daily basis and is unable now.

Occupational history.

Patient is an independent consultant and owns her own home-based company. She works from home and is looking to expand in the future. She attends some international conferences which requires travel on occasion.

Functional limitations.

M.H. leads a mentally and physically taxing lifestyle. Prior to surgery she was engaged in sports and physical activity and thus desires to return to them as soon as possible. Post-surgery, weight bearing is contra-indicated for the initial recovery phase (first 6 weeks) and thus she cannot load the lower left extremity requiring *walking with the aid of crutches*. Her left knee joint is restricted in flexion thus *restricting sitting* with bent knees (minimum 90° required). *Prone-lying position is forbidden* at this time due to anterior pressure on knee joint complex. This limitation forces the patient to sleep on her back which has caused complaints of a sore back and neck. Overall, pain in the leg is not a limiting factor and the patient rates her functional restriction in daily activities as 8 out of 10.

ADL – activities of daily living.

Post- surgery, the patient is able to take care of herself in terms of grooming, dressing, and going to the toilet unassisted. Activities that require prolonged standing and simultaneous hand grasping such as cooking or cleaning furniture overhead is challenging due to crutches and/or one leg standing. She is adapting to ascending stairs with crutches however feels fatigued easily and prefers sitting. Also, sleeping is affecting her negatively since she is restricting to the supine-lying position whereas she is naturally a side sleeper. She is aroused from sleep numerous times at night due to a sore neck and back.

Abuses: Patient is a non- smoker and abstains from any alcohol consumption.

Allergies: None.

Previous rehabilitation.

In May 2010, patient underwent rehabilitation for low back pain in Monada Clinic in Prague which included Mackenzie exercises and various trunk stabilization techniques. Previous to that she underwent the standard rehabilitation for Post- ACL reconstruction surgery From April 1996 to June 1996 at Bulovka Hospital, Orthopedic Rehabilitation division in Prague which included isometric exercises of muscles and mobilization of the knee.

Patient's health documentation extract.

In January 2014, Patient performed a post-surgery follow up visit. Enclosed in the medical document is the following:

Comminuted (splintered/crushed) Fracture of the proximal tibia – left lateral plateau. The knee is with mild swelling. X-ray indicates normal post-surgery state, fixating screws are rigidly in place. The ligamentum patellae is without rupture. Presence of hypotrophy of left thigh muscles is apparent. Left knee has a restricted but painless motion, notable stiffness.

Indicated rehabilitation.

The Orthopedist has indicated 10 therapy sessions. Icing of the knee, mechanical investigation of knee joint complex accompanied by mobilization of the knee. Strengthening of left quadriceps muscle. Fix the orthotic knee brace from 0 to 30° flexion for first 2 weeks. Walk gradually with crutches up to 6 weeks post-surgery. Immediate weight-bearing is prohibited and patient should proceed as per surgeon's suggestions and when weight-bearing is tolerated with underarm crutches. Further RHB recommendations are to be made by treating physiotherapist. The orthopedist has also indicated Magnetotherapy.

Differential considerations.

Edema and swelling causing pain and restriction in knee joint complex. Post-surgical pain and tenderness in the local area of the scar. We can expect motor function deficits in lower extremity especially in quadriceps, triceps surrae, and gluteal muscles accompanied by reflex changes in left foot and calf. Due to immobilization, blockages in the proximal and distal joints to the knee especially the region of the foot as well as decreased range of motion in the joints of the lower extremity.

The possibility of peroneal nerve injury and associated sensory abnormalities may exist. Pelvic asymmetry and tilt due to maintaining a raised left leg while walking on crutches may be exacerbated. Shoulder and neck strain from underarm crutches. Also, Hypotrophy of thigh and calf muscles is to be expected.

Patient is currently underweight for her age and height. She had childhood problems with malnutrition. This may have translated into mineral bone deficiencies in adulthood which makes long bones, such as the tibia, particularly susceptible to fracture upon stress. A constitutional weakness of knee stabilizers may also be a contributing factor since she sustained a separate ACL injury to the right knee in the past.

3.3. Initial Kinesiological Examination

Performed on 07.01.2014

Note* knee brace and anti-thromboembolic bandage were removed as well during examinations.

Present state.

Weight: 54kg Height: 178cm BMI: 17.04 kg/m2

- **Static posture evaluation**

Performed according to Kendall (33)

Posterior view

Note***** Patient is using left crutch while standing due to loading restriction.

Wide base between feet. The right ankle is pronated. The left popliteal region is slightly swollen. Pelvis is not in a neutral position (will elucidate position further in anterior view). Spinal processes clearly visible and are not in proper alignment, there appears a lateral deviation of thoracic vertebrae to the right, indicating presence of scoliosis. Scapulae are abducted on both sides. Hypertrophied trapezius visible on both sides of neck.

Lateral view

Note* with loading of right lower extremity only.

Ankle joint is in plantar flexion and the knee is posterior to the plumb line revealing slight hyperextension. Hip appears slightly flexed and pelvis tilted anteriorly. Lumber spine is highly lordotic while the thoracic spine is in increased flexion and very kyphotic. The cervical spine is hyperextended with the head jutting forward in a protracted position.

Anterior view

Note* Patient is using the left crutch while standing due to loading restrictions.

The transversal and longitudinal arches are present and loading is uniform throughout the foot. The right ankle appears pronated, as in the posterior view. The right patella is very

prominent and visible, however neutral. On the other hand, the left patella is swollen and almost twice the size of the right one. The left thigh appears shrunken compared to the right. The pelvis is raised on the left side and lowered on the left suggesting a lateral tilt. The trunk is rotated slightly to the left and costal ribs are prominent on this side. Clavicles are symmetrical. The head is slightly tilted to the left.

- **Gait analysis.**

According to Kendall (33)

Note* Patient performed gait assessment with the assistance of underarm crutches. This examination will shed light on her "*swing – to gait*" walking stereotype. Also, joint alignment and possible presence of muscle imbalances will be observed.

Forward walking; "swing-to Gait":

Patient placed both crutches forward at the same time, about 30 centimeters in front, and 12 to 16 centimeters to the sides of the toes.

She pushed against the handles and straightened the elbows while shifting her weight forward. Finally, she swung her body to a point between the crutches.

Patient was able to perform this type of gait efficiently and pain-free. However, there was a large protraction and forward propulsion of the head including a marked lateral tilt of pelvis to raise the left leg and aid with knee flexion. Patient appears coordinated yet slightly unstable, this is further evidenced by her glancing down at her feet while walking. Her lumbar lordosis was very pronounced and there appears to be a very unstable thoraco-lumbar junction and lateral hip stabilizers as she swayed from side to side while walking.

Dynamic spine test.

Note* Patient performed tests in the sitting position.

Forward flexion - is restricted until thoracic region ending at the level of last costal margin. Movement is free of pain.

Lateral bending - physiological on the right side (22cm difference between initial and ending position of fingers), Left side is restricted with a 17 cm difference.

Back bending – patient was hesitant to perform this movement, reported feeling slightly stiff and that she doesn't prefer to execute this test.

- **Balance and proprioceptive tests.**

Trendelenburg test while loading right leg only was negative. Vele's test was negative on right foot. The Rhomberg test in positions 1, 2, and 3 was not performed due to inability to load both legs.

- **Pelvic examination.**

Iliac crests are not level. The left iliac crest is higher than the right by approximately 1.0cm. Anterior superior iliac spine (ASIS) is raised higher on the left compared to the right. Posterior superior iliac (PSIS) is raised higher on the left compared to the right.

- **Neurological examination**

Deep tendon reflexes

Grading according to Vele's scale (0-5, 3 indicates presence of reflexes)

Due to the use of underarm crutches for a length of time, risk of brachial plexus injury is heightened from pressure and compression to the axilla, thus, upper extremity deep tendon reflexes were checked as well.

Biceps reflex (C5), radial reflex (C6), triceps reflex (C7), and finger reflex (C8) all present at grade 3. Patellar reflex (L2-L5), present bilaterally at grade 3. Achilles reflex (L5-S2) present bilaterally at grade 3 but hypo-reflexive on left side at grade 2.

Deep sensation

Position sense: tracing the heel along the contralateral tibia from cranial to caudal direction (right heel only). The patient was able to perform it successfully.

Position movement sense: Patient lifted her right leg and successfully matched its position with the other leg in elevation.

Dermatomes and superficial sensation.

Note* Traumatic injury to the knee and use of a tight knee brace poses a particular risk to peroneal nerve neuropathy, especially for very thin patients such as M.H.

All relevant dermatomes (L1, L2, L3, L4, L5, S1, and S2) were tested and had intact sensation, pressure registration, and temperature recognition.

Dorsiflexion and toe extension against resistance was performed successfully to test for peroneal nerve innervation.

- **Breathing stereotype examination.**

Performed according to Lewitt (16)

Patient is in supine - lying position and is asked to breathe normally, this test was also performed in standing. M.H. is generally an abdominal breather however, at some instances we can observe the breathing cycle erupt into paradoxical breathing and then back to normal, diaphragmatic breathing. In supine position, the lower ribs are particularly flaring out during inspiration. She takes an average of 23 breaths per minute.

- **Basic movement patterns**

Performed according to Janda (25)

Trunk flexion - Patient performed this movement three times, observations were made on the second movement. Motion is fluid and without pain. Patient was able to sit up erect without any shaking of the trunk and while lower extremities remained flat on table. Abdominal and hip flexor interplay was balanced. Optimal movement pattern activated.

Hip extension - again patient performed the movement three times in the prone position and the second stereotype was analyzed. Hip extension is an important movement within the gait cycle and could give us valuable information as to the patient's ability to return to normal gait.

The sequence of muscle activation was faulty – instead of beginning by contracting the gluteaus maximus muscle and then the hamstrings, M.H. starts with her contralateral lumbar spinal extensors. She is unable to keep her pelvis flat on the table during this movement.

- **Anthropometry**

Measurements were taken while patient is in supine-lying position using a measuring tape (in cm) for both lower extremities. Tape is placed on anatomically relevant bone landmarks.

Circumference	**Dexter (cm)**	**Sinister (cm)**
Ankle	11.5	12.5
Calf	18	15
Knee Joint	14	17
Thigh	45	40
Length	**Dexter (cm)**	**Sinister (cm)**
Foot	23	23
Middle leg	44	43.5
Thigh	61	60.5
Anatomical length of lower	105	105

extremity		
Functional Length of Lower extremity	104	105

Table 8 – Initial anthropometric measurement of lower extremities.

- **Palpation of muscle tone and trigger points.**

	Dexter		**Sinister**	
	Tonus	**TrPs**	**Tonus**	**TrPs**
Tibialis Anterior	hypertone	**yes**	hypotone	**No**
Soleus	eutone	**No**	hypotone	**No**
Gastrocnemius	hypertone	**Yes**	hypertone	**No**
Hamstrings	eutone	**No**	hypertone	**Yes**
Quadriceps	hypertone	**No**	hypotone	**No**
Iliopsoas	hypertone	**Yes**	hypertone	**Yes**
Gluteus Maximus	hypertone	**No**	eutone	**No**
Gluteus Medius	eutone	**No**	eutone	**No**
Piriformis	hypertone	**Yes**	hypertone	**Yes**
Tensor Fascia Lata	hypertone	**No**	eutone	**No**

Table 2 – Palpation of muscles of hip and lower extremity.

Range of motion (Goniometry).

Performed according to Kendall (33)

- Aids: two-arm goniometer

Lower Extremities

1. Hip joints

	Type of Motion	**F**	**E**	**ABD**	**ADD**	**IR**	**ER**
Dx	Active	130 °	15 °	45 °	10 °	30 °	45 °
	Passive	135 °	20 °	50 °	15 °	35 °	50 °
Sin	Active	120 °	**8** °	**30** °	**5** °	30 °	**30** °
	Passive	120 °	**10** °	**35** °	10 °	35 °	**35** °

2. Knee joints

	Type of Motion	F	E
Dx	Active	130 °	0 °
	Passive	135 °	0 °
Sin	Active	**35** °	0 °
	Passive	**40** °	0 °

3. Ankle joints

	Type of Motion	Dorsal F	Plantar F	Inversion	Eversion
Dx	Active	20 °	45 °	35 °	15 °
	Passive	25 °	45 °	40 °	20 °
Sin	Active	20 °	**40** °	25 °	**10** °
	Passive	25 °	45 °	30 °	15 °

4. Metatarsophalangeal joints:

		Type of Motion	F	E
Dx	1st digit	Active	45 °	30 °
		Passive	50 °	30 °
	2nd digit	Active	40 °	30 °
		Passive	35 °	20 °
	3rd digit	Active	30 °	30 °
		Passive	35 °	40 °
	4th digit	Active	20 °	40 °
		Passive	40 °	45 °
	5th digit	Active	35 °	60 °
		Passive	45 °	65 °

Sin	1st digit	Active	45 °	30 °
		Passive	45 °	30 °
	2nd digit	Active	40 °	30 °
		Passive	40 °	25 °
	3rd digit	Active	40 °	25 °
		Passive	40 °	25 °

	4th digit	Active	40 °	30 °
		Passive	45 °	35 °
	5th digit	Active	40 °	30 °
		Passive	50 °	40 °

5. Inter-phalangeal joints

		Type of Motion	**F**	**E**
Dx	1st digit	Active	40 °	80 °
		Passive	40 °	90 °
	2nd digit	Active	55 °	0 °
		Passive	60 °	5 °
	3rd digit	Active	60 °	0 °
		Passive	65 °	5 °
	4th digit	Active	60 °	0 °
		Passive	60 °	10 °
	5th digit	Active	60 °	0 °
		Passive	70 °	5 °
Sin	1st digit	Active	40 °	90 °
		Passive	40 °	90 °
	2nd digit	Active	55 °	0 °
		Passive	60 °	5 °
	3rd digit	Active	60 °	0 °
		Passive	60 °	10 °
	4th digit	Active	60 °	0 °
		Passive	65 °	5 °
	5th digit	Active	60 °	0 °
		Passive	70 °	0 °

Table 3 - Initial examination of active and passive ROM of lower extremity.

Muscle length testing.

Performed according to Janda (25)

Shortness grade scale: **0** - No shortness, **1**- moderate shortness, **2** - marked shortness

Examined Muscle	Dexter	Sinister
Iliopsoas	1	3
Rectus Femoris	1	1
Tensor Fascia Latae	1	1
Sartorius	0	0
Hip Adductors	0	0
Gluteus Maximus	0	0
Gluteus Minimus	0	0
Gluteus Medius	0	0
Piriformis	0	0
Hamstrings	0	1
Gastrocnemius	1	1
Soleus	0	1
Tibialis Anterior	0	0

Table 4 – Initial examination of muscle shortness according to Janda.

- **Manual muscle strength testing (MMT).**

Performed according to Kendall (33)

Kendall MMT Grading scale: **Zero grade (0)** – no contraction palpable, **Trace grade (1)** – visible or palpable contraction, **Poor grade (2)** – ability of muscle to move in horizontal plane without force of gravity **Fair grade (3)** – muscle can hold test position against gravity only, **Good grade (4) -** ability to resist against moderate pressure throughout entire ROM range, **Normal grade (5)** – Holds test position against strong pressure.

Note* sub-classifications of key grades with + or – values are applied according to gradations in muscle strengths and judgment of examiner's feedback. Strength testing was performed according to Kendall's suggested order from 1. Supine, 2. Side-lying, 3. Prone, 4. Sitting.

Muscle / Group	Grades for Right side	Painful Arc	Grades for Left side	Painful Arc
Toe Extensors	5	No	5	No
Toe Flexors	4+	No	**4+**	No
Tibialis Anterior	5	No	**4+**	No
Tibialis Posterior	5	No	5	No
Peroneals	**4+**	No	**3+**	**Yes**

Tensor Fascia Latae	**4+**	**Yes**	5	No
Sartorius	5	No	5	No
Iliopsoas	5	No	5	No
Gluteus Medius	5	No	**4-**	No
Gluteus Minimus	4+	No	**4-**	No
Hip Adductors	5	No	5	No
Gastrocnemius	5	No	**4-**	No
Soleus	5	No	**4-**	No
Hamstrings	5	No	5	No
Gluteus Maximus	4	No	**3+**	No
Quadriceps	5	No	**4-**	**Yes**
Piriformis	**4+**	No	**4+**	No
Medial Hip Rotators	5	No	5	No
Hip flexors (group test)	5	No	5	No

Table 5 – Initial manual testing for strength of lower extremity according to Kendall.

- **Joint play**

Performed according to Lewitt (16)

Key to examination tables is as follows:

0 - Indicates no blockage at the joint and reaching of physiological barrier

X - Restricted/ hard barrier

XX - Restricted and painful barrier

1. Proximal and distal phalanges of right lower extremity					
	I digit	II digit	III digit	IV digit	V digit
Dorsal	0	0	0	0	0
Ventral	0	0	0	0	0
Latero-lateral	0	0	0	0	0
Rotation (*Rx*)	0	0	0	0	0
2. Proximal and distal phalanges of left lower extremity					
Dorsal	0	0	0	0	0
Ventral	0	0	0	0	0
Latero-lateral	0	0	0	0	0
Rotation (*Rx*)	0	0	0	0	0
3. Metatarsal-phalangeal joints of right lower extremity					

	I digit	II digit	III digit	IV digit	V digit
Dorso-ventral	0	X	X	0	0
Rotation (*Rx*)	0	0	0	0	0
4. Metatarsal-phalangeal joints of left lower extremity					
Dorso-ventral	0	X	X	0	0
Rotation (*Rx*)	0	0	0	0	0
5. Lisfranc joint					
	Right LE			Left LE	
Dorsal	0			0	
Plantar	0			0	
6. Chopart's joint					
	Right LE			Left LE	
Dorsal	0			0	
Plantar	0			0	
7. Talocrural joint					
	Right LE			Left LE	
Ventral	0			0	
Plantar	0			0	

Table 6 - Joint play examination of the foot and ankle of lower extremity.

1. Tibiofibular joint (head of fibula)		
	Right LE	Left LE
Ventral	contraindicated post-surgery	contraindicated post-surgery
Dorsal	contraindicated post-surgery	contraindicated post-surgery
2. Knee joint		
	Right LE	Left LE
Medial	0	0
Lateral	0	0
Anterior	0	X
Posterior	0	X
3. Patella		
	Right LE	Left LE
Ventral	0	X
Caudal	0	XX
Later-lateral	0	0
Circumduction	0	X

Table 7 - Continuation of examination of joint play of lower extremity.

3.3.1. Summary of initial kinesiological examination.

Initial physiotherapeutic examination of patient M.H. reveals that structural changes in the lower extremity during injury and presently, after surgery, has resulted in muscular and articular restrictions resulting in restricted range of motion, especially that of the knee joint. There are both adaptive shifts in posture and loss of muscle trophy which will require correction and rehabilitation respectively in M.H.'s course of therapy. Citied below are the main observations in chronological order of appearance, of all examinations performed during initial examination of the patient (section **3.3**.). Examination conclusions with the most critical bearing on M.H.'s clinical therapy is as follows:

Posture evaluation reveals a kyphotic-lordotic posture with slight scoliosis to the right in the thoracic segment. Due to maintaining a semi-flexed knee (while crutch-walking) on the operated extremity and to avoid contact with the floor, M.H. has elicited aid in raising the extremity using her pelvis this results in acquired patterns of muscle imbalances. As is common in kyphotic-lordotic posture, and as is observed with M.H., there is a marked anterior tilt of the pelvis with its complementary lordosis in the lumbar spine, this may be the cause of increased strain on the low back thus explaining the previous complaints in of pain in that area however, tight low back extensors are not noted according to inspection.

Congruent with the typical features of such a posture we also observe weakened hip extensors. The protracted position of the head compensates for the exaggerated kyphosis of the upper thorax and may explain her current complaint of strain in the cervical region. As for gait, the patient seems to manage crutch-walking with proper implementation of swing-to gait stereotype.

Significant findings from **anthropometry** of lower extremities reveals an asymmetry between both with the right shorter by 1cm due to increased loading after surgery. Of particular significance is the reduced circumference of calf and thigh muscles on the operated lower extremity which will have to be strengthened and rehabilitated.

Palpation of muscles indicates hyper tonicity of hip flexors due to severe anterior tilt of pelvic combined with strain on right hip and necessity of maintaining flexed position of

right hip to prevent touch down of left foot. Generally, patient is exhibiting both a state of hypertonic and hypotrophic muscles of left lower extremity.

Goniometry sheds light on the restricted motion of the left knee reaching only 30° of active flexion from neutral. Joint play is intact overall with blockages featuring between 2nd and 3rd phalanges, the insertion point of m.tibialis posterior, a common syndrome within the general population. Other major restrictions, are of the right patella and knee in anterior and posterior directions mainly due to swelling, muscular length discrepancies between agonists and antagonists as well as muscle power imbalance.

3.4. Short & Long- Term Physiotherapy

3.4.1. Short-term physiotherapy plan.

The patient is undergoing this case study during her sub-acute stage as an outpatient, goals will be to manage soft tissue inflammation, swelling, and edema around knee joint. Maintaining non-weight bearing (NWB) on the affected leg for first 4 weeks and to gradually increase weight-bearing as per surgeon's assessment of radiographic evidence of healing. Prevent knee stiffness and loss of ROM by encouraging early mobilization of the knee. The goal is to gain 90° flexion in the knee by 4 weeks post-operatively. Also, the patient must obtain full extension and as much flexion in the knee as the patient can tolerate without pain.

A crucial goal is to strengthen muscles of the anterior thigh compartment especially the VMO (Vastus Medialis Oblique), and Rectus Femoris including the ankle flexor group with the aim being to restore muscle trophy and contractile power. We must ensure Restoration of muscle elasticity to any shortened and hypertonic knee flexors (hamstrings) and hip flexors. Finally, ensuring the patient is independent in transfers, short distance ambulation and stairs, while maintaining NWB (Non weight-bearing status). During treatment, the patient will be educated about her daily home exercise program/ self- therapy.

3.4.2. Long-term physiotherapy plan.

To maintain all improvements gained in the short-term plan. Increase proprioception in lower extremities especially the knee and foot complex. Condition the muscles of the trunk to provide core stabilization. Finally, to stabilize muscles and ligaments around the knees to provide structural support during standing, walking, running and continuation in autotherapy.

3.5. Therapy Progress

Day to Day therapy

Date: 08. 01. 2014

Current status: *Subjective* – Patient is very enthusiastic to start the treatment. She has a high positive esteem towards improving her condition. Her main complaint is knee stiffness and a sore back from being restricted to a supine-lying position.

Objective – (See Initial Kinesiological Examination) Patient has great limitations in ROM especially in knee flexion. Movement is without pain and the patient subjectively feels that it is from stiffness.

Objective of Today's Unit: Assess and restore tissue motility around the scar and calf fascia. Mobilize the knee joint. Alleviate pain felt in the low back due to crutch-walking and overnight sleeping in supine. Apply indicated physical therapy.

Therapy applied:

Scar tissue was moisturized by an emollient cream, S-curve pressure applied on scar by therapist. No pain or tenderness was felt by patient upon touch in post-operative scar. Calf fascia and thigh fascia mobilization was performed on left extremity.

Patient in prone-lying position and stretching of the lumbo-dorsal fascia, and kibbler folds was performed to alleviate the strain on the back.

Breathing therapy: localized, diapraghmatic breathing while patient is in supine-lying and knees brought to maximal reachable flexion – in order to achieve a flat low back.

PIR on left triceps surrae muscle including a passive stretch of calf muscles into dorsal and plantar flexion of the ankle.

Repeated passive, assisted mobilization of the knee was performed by the therapist, approximate maximum flexion reached before pain was felt is approximately 45°.

Physical therapy

Modality: pulse magnetotherapy

A 20 minute session was performed on the patient after exercises.

Results: Patient experienced ample relief from soft tissue techniques performed on the back and has expressed that she will consider seeking massage therapy on a regular basis. After passive mobilization of the knee, patient felt some more pain however she reported that maximum flexion (45°) is reached with more fluidity, as in she does not experience a hard barrier.

Self-therapy: Patient asked to practice localized breathing at the onset of low-back pain by placing her hand on the lower abdomen and breathing into them. Also, using the aid of an over-ball placed under her left foot, she is to perform repeated knee flexion 5x/day.

Day to day therapy

Date: 09.01.2014

Current status: *Subjective* – patient is in high countenance. Does not feel much change overnight but felt a positive outcome from following the self-therapy advice. She is eager to partake in active exercises today.

Objective – knee appears more swollen than the last visit. According to patient, she feels the increase in its size after engaging in auto-therapy at home. Patient's body temperature is slightly depressed at 36.4°C. she is wearing a thick jacket.

Objective of today's unit: reduce knee swelling. Mobilize the joints of lower extremity. Relax the knee flexors and extensors. Relax the tightened hip flexors. Condition the quadriceps muscles and begin VMO activation.

Therapy applied:

To achieve a cumulative/ continuous effect, the same previous therapy (08.01.2014) was applied at the start of the session.

Additional therapy: patient instructed to repeatedly point the toes and release them and to perform circumduction o the ankle. Following this, manual lymphatic draining techniques was performed on left lower extremity to increase venous perfusion and reduce fluid buildup in knee.

Post-Isometric relaxation of rectus femoris, hamstrings and finally iliopsoas according to Kendall's. Patient reports distinctly feeling the sensation of release at the hip.

VMO activation exercises

1) Soft ball squeezes

Patient is supine with a foam ball placed under her knees in the popliteal fossa. Patient's task is to "squeeze" the soft ball by actively using her quadriceps muscle to extend the knee and straighten it. The exercise was performed 20x, patient exhibited disruption of muscle synergy after 10 repetitions and was eliciting the aid of her gluteal muscles to press the ball more toward the table.

2) Patella lifts in ventral direction

Patient is sitting with legs extended on a flat surface, her palms are flat on the surface by her side. The therapist presses at a point slightly ventral to the knee caps, anatomically corresponding to the insertion of the quadriceps muscle, in order to facilitate it and orient the patient. The patient is instructed to lift the patella in a ventral direction as if performing a

patella “lift”. Here the emphasis was placed on the patient feeling the activity of the quadriceps muscle and visually being able to see the result of that activation, i.e. the patella moving ventrally.

3) Breaking exercise

Patient is sitting on the edge of the table. She extends her knee fully. The therapist is putting pressure toward flexion on the patient’s shinbone. The patient tries to resist this action by maintaining extension and breaking the pressure. This was performed 10x.

Results: post-therapy knee flexion examination reveals flexion of 50°, a 5° improvement since yesterday. Also the level of exertion the patient displayed in activating the muscles reveals that her thigh muscles are very unconditioned leading us to modify day to day therapy to include even more quadriceps strengthening exercises.

Self-therapy: patient is to continue with soft ball squeezes implementing it 3x a day. VMO activation with patella lifts is also indicated 3x a day. Icing of the knee is highly stressed upon as the patient is presenting, for the 2nd therapy session, again with a swollen knee. Application of ice packs recommended at least 4x a day or as needed.

Day to day therapy

Date: 10.01.2014

Current status: *Subjective* – patient is highly motivated and reports that she is able to sit now with a semi-flexed knee instead of fully extended. However, she also reports pain in the popliteal fossa of the left leg. The pain is more marked after exercising at home.
Objective – knee is slightly swollen. Popliteal fossa has a bluish coloration.

Control examination: goniometry of the knee goniometry reveals that patient has reached 55° of flexion

Objective of today's therapy: restore joint play by mobilizing the joints of the lower extremity. Lengthen shortened muscles with passive stretching prior to resuming with VMO activation.

Therapy applied:

Manipulation of Achilles tendon to release the shortened tendon on the right foot due to continuous loading without the aid of the left foot.

Mobilization of the metatarsophalangeal joints, the Lisfranc, Chopart, knee joint, and patella of LE. Mobilization of the head of fibula was not performed upon instructions from the supervisor, as it including too risky of a maneuver and might disrupt the implanted screw in the lateral tibial plateau.

Passive, therapist assisted stretching of the following muscles: tibialis anterior, triceps surrae, quadriceps (specifically mid-region in the rectus femoris), hamstrings, iliopsoas, piriformis, and adductors which were quite painful upon stretch → therefore, PIR was simultaneously performed on the adductors. The upper limit for stretching each muscle was the patient's pain threshold, and the stretch position was held at 5 seconds each.

Eccentric and concentric strengthening of gluteal medius in side lying position. Strengthening of gluteal muscles against resistance in prone-lying position.

<u>VMO Activation</u>

The same VMO exercises performed on 09.01.2014 were repeated including an addition of the following exercises:

1) Flexion/ extension of the knee against resistance

   Therapist holds the patient's left foot and the patient starts with maximum flexion. Patient is asked to straighten the leg against therapist resistance and bring it back into flexion. 10x/ 2 sets.

   Note* Patient required a lengthy period of rest in between.

2) Isometric contractions of quadriceps muscle

   A pillow is placed underneath the patient's knees and the patient is asked to imagine squeezing the pillow and holding this position for 3s each time. This is performed 15x for 2 sets.

Physical therapy

Modality: pulse magnetotherapy

A 20 minute session was performed on the patient after exercises.

Results: Control examination of muscle length test according to Janda was performed on hip flexors and no shortness was found (grade 0). Patient reports a revitalized feeling after stretching and therefore more auto-stretching will be included in self-therapy. Flexion of the knee is now 60° after therapy, this translates into a 5° gain in the span of 1 therapy session. Patient is delighted with the prospect of being able to perform sitting ADL more comfortably.

Self-therapy: Patient is to stretch the adductors, Calf muscles, hamstrings and rectus femoris with an inflexible band/ towel at home both in the morning and before sleeping. When lying in bed, in either supine or prone position, M.H. is to perform isometric gluteal squeezes for muscle conditioning. Isometric contractions of quadriceps muscles with the aid of a pillow is also to be continued with. Contra-indication: watch out for hyperextending the knees to prevent undue pressure on osteosynthesis and the popliteal fossa. Patient instructed not to lock the knee when performing quadriceps isometrics.

Day to day therapy

Date: 13.01.2014

Current state: *Subjective* – patient feels no pain in the knee region. She is implementing her auto therapy strictly as instructed and feels that the mobility restriction is lifting from her knee. Also, localized icing is providing relief while hot water baths is relaxing to her global musculature.

Objective – pre-therapy examinations to mark progress, goniometric measurement of knee flexion = 65°, this progress in ROM has been made possible with a strict 3 day implementation of auto-therapy.

Self-therapy: To continue performing slow, gentle passive ROM to the joints around the fracture site. To continue with isometric and resistive exercises to muscles of the knees.

Goals of today's therapy: strengthen auxiliary muscles of the lower limb. Post-isometric relaxation followed by functional training of muscles of the knee for stability (without loading and using the aid of an overball).

Therapy applied:

Therapy from previous session (10.01.2014) was repeated at the start.

Strengthening exercises

1) Abduction of lower extremity

   Patient is supine-lying and stabilizes herself with both arms by the side while abducting the extended leg 10x on each side for 2 sets. Patient has a physiological range of motion and can perform this with a great deal of control.

2) SLR: straight leg raises

Patient sat with her legs straight out in front of her. The knee of her non operated leg is bent to a 90° angle keeping her foot flat on the floor. Slowly lifting the operated leg six inches off the floor (by contracting the front thigh muscles. She held this position for five seconds. Slowly lowering her leg to the floor. She Relaxed and repeated 10 more times.

3) Adductors isometrics

Placing an overball filled with 50% air between the knees, the patient is lying supine. She bent her knees (into maximal possible flexion) and she squeezed the ball between her knees thus performing isometric contractions. This trains the hip adductors and is performed 10x for 2 sets.

4) Hip Bridges

Laying on her back, feet flat and hip-width apart, arms relaxed, and knees bent, the patient contracts her gluteals and lifts her hips creating a straight line from the knees to the shoulders. She holds for a slow count of 3 seconds, then lowers slowly. This exercise conditions hamstrings, gluteal muscles and reduces pressure on spinal column. Exercise repeated for 10x and 2 sets.

5) Quadriceps

Placing an overball filled with 30% air under the knee, the patient is laying on her back and attempts to lift her ankle from the bed. She holds the position for 3 seconds (full extension of the knee) and gently lowers the leg.

6) Continuous flexion/ extension with resistance

Patient is prone and performs flexion and extension of the knee in both directions while therapist provides resistance. This is performed 25x for 2 sets. This exercise strengthens knee flexors and extensors.

Physical therapy

Modality: pulse magnetotherapy

A 20 minute session was performed on the patient after exercise.

Post-therapy examination:

Length test for rectus femoris *according to Kendall (33),* result is (0) or no shortness. Goniometric measurement reveals maximal flexion at 80°.

Results: Knee flexion is markedly improved at 80° over a 3 day period, this is attributed to the patient's conscientious application of mobilization exercises at home. Patient has more control over knee flexors and extensors in terms of coordination and stability.

Self-therapy: isometric exercises of the quadriceps for continued VMO activation, at least 3x/day. Strengthening exercises of the anterior thigh compartment and hamstrings. Continuous active movement into flexion and extension of the knee.

Day to day therapy

Date: 15.01.2014

Current state: *Subjective* – patient reports being busy and unable to perform the last indicated auto-therapy as diligently. She feels no pain in the anterior region of the knee only some pressure in the popliteal fossa. Patient states that she is now able to sleep overnight in the prone position which is providing much needed relief from the supine lying position. Previously she was apprehensive to apply bodily pressure on the anterior aspect of the knee. Supervising physiotherapist has instructed her to attempt to sleep prone and overcome this anxiety as it is no longer a contra-indication.

Objective – pre-therapy examination of the calf fascia reveals slight restriction in the left calf. Knee flexion has reached 90° despite the patient being unable to implement auto

therapy. The Thomas test *according to Kendall (33)* indicates no shortness in the rectus femoris, however, it is crucial to continue with gentle stretching of this muscle.

Goals of today's therapy: To challenge the patient by introducing variations to the strengthening exercises of the lower extremities particularly PNF techniques *according to Kabat* now that the patient has reached the aim of 90° knee flexion . Apply PIR to key muscles of the lower extremities. Maintain knee flexion at 90° and encourage a larger ROM (>90°).

Therapy applied:

PIR of iliopsoas followed by palpation of trigger points and trigger point therapy – localized pressure on the point of hypertonicity until release is achieved. This was quite painful to the patient.

PIR treatment for rectus femoris, triceps surrae, adductors and tibialis anterior muscles on both the right and left lower extremity.

Prior to implementing PNF techniques in the 1F and 1E diagonals, rhythmisation was performed to guide and introduce the patient to this sophisticated motion.

PNF technique of repeated contractions, 1st flexion diagonal followed by 1st extension diagonal was performed 5x. A three minute pause was taken and we resumed this exercise for another 5x.

<u>Single leg bridge exercise</u>

Same position as exercise 4 performed on 10.01.2014 with extension of the left leg. Patient slowly raises and extends her leg while keeping her pelvis raised and level, trying not to let one side dip down. Exercise aims to isolate and strengthen gluteal muscles, hamstrings and improve core and spinal stability.

<u>Side planks</u>

Patient starts in the side lying position. She stabilizes herself on her the flexed elbow. She lifts her body off the ground and balances on one forearm and the side of her foot. Aim is to isometrically contract her abdominals and relax her shoulders while breathing. This exercise is to encourage core stability and overall conditioning after surgery.

Post-therapy examination:
Improvement in joint play of patella in all directions
No shortness of gastrocnemius and soleus muscle (grade 0)

Results: patient expressed being mentally intrigued in performing the PNF diagonals and wishes to continue in this specific therapy for remaining session. She also felt that the post-isometric therapy was pleasant providing a sense of release.

Self-therapy: Patient instructed to continue with hip bridge exercises, also she has been shown how to perform self- mobilization of the patella in all directions. Gravity-induced post-isometric relaxation of the iliopsoas by having the lower extremity hang off the edge of the table/bed will be helpful in releasing hip flexor tightness. In terms of VMO activation, patient is to continue with "patella lifts in ventral direction" described in day 09.01.2014 to strengthen quadriceps, 3x/day.

Day to day therapy:

Date: 17.01.2014
Current state: *Subjective* – patient is excited to be able to touchdown with her left foot. She reports that icing is providing a needed relief after performing home exercises. She has also been experiencing cramping in her left foot, specifically between the 2nd and 3rd metatarsophalangeal joints.

Objective – Patient consulted with the orthopedic physician on 16.01.2014. He has recommended that non-weight bearing (NWB) status is terminated and that 30% loading or

more with the limitation being slightest pain provoked. Also, fixation with an orthotic knee brace is no longer mandatory. X-rays of the left tibia reveal physiological healing in fracture site. Patient has improved in all parameters of the therapy, especially indicated by flexion reaching 110°.

Goal of today's therapy: Provide soft tissue techniques on the lower extremities, mobilize joints of the foot. Continue with PNF strengthening techniques, to overcome remaining barriers in the ROM by relaxation of hypertonic muscles through PNF relaxation techniques. Begin stationary bike training (low speed) since patient is allowed to weight-bear now. Teach the patient proper sitting and standing posture, now that use of her left foot is mandated.

Therapy applied:

Kibbler folds and fascia mobilization on both calves and thighs to obtain release. Soft ball techniques applied on scar tissue and knee region.

Mobilization therapy consisting of fanning of the foot (spreading of the metatarsals). Mobilization of the 2nd and 3rd metatarsophalangeal joints followed by mobilization of Lisfranc, Chopart and talo-crural joint.

Traction of the talo-crural joint in the ventral direction. Traction of the hip joint along the axis of the femur and femoral head was performed once by the therapist until release was obtained

Active movement on behalf of the patient towards ankle plantar and dorsiflexion. Repetitive eversion and inversion active movements.

PNF technique *by Kabat* (31) in lying position – 1st diagonal flexion and extension patterns for lower extremity, followed by 2nd diagonal flexion and extension patterns - repeated contractions for strengthening of iliopsoas, pelvic floor muscles, adductors, vastus medialis

and lateralis, gluteus maximus, medius and minimus. Also, tibialis anterior and posterior, peroneus longus and brevis including toe flexors and extensor.

PNF technique implemented again, this time all the above diagonals were utilized in Hold-relax, contract-relax techniques (5x each).

Patient was asked to imagine inscribing the alphabets with her toes. This exercise requires the movement of the ankle complex in all planes of motion thus activating the deep peroneals, triceps surrae, and both tibialis posterior and anterior.

Finally, the patient performed gentle cycling on a stationary bike with minimal resistance for 15 minutes, 3 minutes pause, and afterwards another 15 minutes. Patient was instructed to apply force on the pedal from the knee apparatus rather than extending the hip.

Physical therapy

Modality: pulse magnetotherapy

A 20 minute session was performed on the patient after exercise.

Results: Quick results can be seen after every PNF performance, especially during the relaxation techniques with an increase of ROM into new points of restrictions. There is no pain during the movements but subjectively just overload pain after the therapy. Foot cramping has eased. Post-therapeutically, goniometric measurement of the knee flexion reads at 120°.

Self-therapy: Patient is to continue with quadriceps strengthening namely, “patella lifts” to stabilize the knee 3x/day for 10 repetitions. Also, hip bridges with single leg raise is to be performed 2x/day for 5 repetitions. Patient was instructed on proper sitting posture: to tuck the chin inwards, posteriorly tilt the pelvis leading to spinal elongation. Also, bringing the shoulder into external rotation and retracting them. Instructions on optimal standing posture, now that some loading is permissible, was also given to the patient.

3.6. Final Kinesiological Examination

Performed on 20.01.2014

*Changes from initial examinations are marked in **bold letters.** Significant therapeutic changes in the tables will be marked in Red.*

Present status.

Weight: **55kg** Height: 178cm BMI: **17.4kg/m2**

- Static posture evaluation

Performed according to Kendall (33).

Posterior view

Note* patient is still using left crutch while standing due to 30% loading restriction.

Narrower base between feet. The right ankle is pronated. The left popliteal region **is no longer swollen**. Pelvis is not in a neutral position. Spinal processes clearly visible and are not in proper alignment, there appears a lateral deviation of thoracic vertebrae to the right, indicating presence of scoliosis. Scapulae are abducted on both sides. Hypertrophied trapezius visible on both sides of neck.

Lateral view

Note* with loading of right lower extremity only.

Ankle joint is in plantar flexion and the knee is posterior to the plumb line revealing slight hyperextension. Hip appears slightly flexed and pelvis tilted anteriorly. Lumber spine **is slightly less lordotic** while the thoracic spine is in increased flexion and very kyphotic. The cervical spine is hyperextended with the head jutting forward (protracted).

Anterior view

Note* Patient is using the left crutch while standing due to 30% loading restriction.

The transversal and longitudinal arches are present and loading is uniform throughout the foot. The right ankle appears pronated, as in the posterior view. The right patella is very prominent and visible, however neutral. On the other hand, **the left patella is less swollen and almost similar in size to the right one**. The left thigh **still** appears shrunken compared to the right, **but markedly fuller than initial state**. The pelvis is raised on the left side and lowered on the left suggesting a lateral tilt. The trunk is rotated slightly to the left and costal ribs are prominent on this side. Clavicles are symmetrical. The head is slightly tilted to the left.

- **Gait analysis.**

Performed according to Kendall (33)

Note* patient performed this gait assessment without the assistance of underarm crutches. She insisted that she can manage at least 20 steps, the supervising physiotherapist encouraged this since some loading of the left lower extremity is recommended by the Orthopedist provided the patient is aware of her pain threshold and took necessary precautions.

She is limping due to the weight constriction, her muscle coordination is intact. She is taking very short, cautious steps. Her arm swing are large and brisk to maintain balance. Most of the loading is on the healthy extremity. The mobility of the left knee is functional, and she has regained enough ROM to enable walking.

- **Dynamic spine test.**

Note* patient performed tests in standing position

Forward flexion - is restricted until the lower thoracic region ending at the level of last costal margin. Movement is free of pain. **Spinal curve deviates to the right**.

Lateral bending - physiological on the right side (22cm difference between initial and ending position of fingers), Left side is restricted with a **19cm difference**.
Back bending – patient **was not hesitant** to perform this movement, movement was fluid, pain free and within physiological range.

- **Balance and proprioceptive tests.**

- Trendelenburg test while **loading both legs** was negative.
- Vele's test was negative on **right and left foot.**
- Rhomberg test in positions 1, 2, and 3 was **performed** and all results are negative.

- **Pelvic examination.**

All findings are similar to the initial examination. The Iliac crests are not level. The left iliac crest is higher than the right by approximately 1.0cm. The Anterior superior iliac spine (ASIS) is raised higher on the left compared to the right. Posterior superior iliac (PSIS) is raised higher on the left compared to the right.

- **Neurological examination.**

Deep tendon reflexes

Grading according to Vele's scale (0-5, 3 indicates present reflexes)
Biceps reflex (C5), radial reflex (C6), triceps reflex (C7), and finger reflex (C8) **all present** at grade 3. Patellar reflex (L2-L5), **present** bilaterally at grade 3. Achilles reflex (L5-S2) **present** bilaterally at grade 3 but **hypo-reflexive** on left side at grade 2.

Deep sensation

Position sense: tracing the heel along the contralateral tibia from cranial to caudal direction (right heel only). The patient was able to perform it successfully.
Position movement sense: Patient lifted her right leg and successfully matched its position with the other leg in elevation.

Dermatomes and superficial sensation.

All relevant dermatomes (L1, L2, L3, L4, L5, S1, and S2) were tested and had **intact sensation, pressure registration, and temperature recognition.**

Dorsiflexion and toe extension against resistance was **performed successfully** to test for peroneal nerve innervation.

- **Breathing stereotype examination.**

Performed according to Lewitt (16)

Patient is in supine - lying position and is asked to breathe normally, this test was also performed in standing. M.H. **Paradoxical breathing is not observed** this time around. In supine position, the lower ribs are particularly flaring out during inspiration. Her inspiratory rate is **25** breaths per minute.

- **Basic movement patterns.**

Performed according to Janda (25)

Trunk Flexion - Patient performed this movement three times, observations were made on the second movement. **Motion is fluid and without pain**. Abdominal and hip flexor interplay was balanced. Optimal movement pattern activated.

- **Anthropometry**

Measurements were taken while patient is in supine-lying position using a measuring tape (in cm) for both lower extremities. Tape is placed on anatomically relevant bone landmarks.

Circumference	**Dexter (cm)**	**Sinister (cm)**
Ankle	11.5	**11.5**
Calf	18	**16**
Knee Joint	14	**15**
Thigh	45	**43**
Length	**Dexter (cm)**	**Sinister (cm)**

Foot	23	23
Middle leg	44	43.5
Thigh	61	**61**
Anatomical length of lower extremity	105	105
Functional Length of Lower extremity	104	105

Table 8 – Final anthropometric measurement of lower extremities.

- **Palpation of muscle tone and trigger points.**

	Dexter		**Sinister**	
	Tonus	**TrPs**	**Tonus**	**TrPs**
Tibialis Anterior	hypertone	**yes**	**eutone**	**No**
Soleus	eutone	**No**	**eutone**	**No**
Gastrocnemius	**eutone**	**No**	**eutone**	**No**
Hamstrings	eutone	**No**	hypertone	**Yes**
Quadriceps	hypertone	**No**	**eutone**	**No**
Iliopsoas	hypertone	**Yes**	hypertone	**Yes**
Gluteus Maximus	hypertone	**No**	eutone	**No**
Gluteus Medius	eutone	**No**	eutone	**No**
Piriformis	**eutone**	**Yes**	**eutone**	**No**
Tensor Fascia Lata	hypertone	**No**	**hypertone**	**No**

Table 9 – Final Palpation of muscles of hip and lower extremity.

• **Range of motion (Goniometry).**

Performed according to Kendall (33)

Aids: two-arm goniometer

Lower Extremities

1. Hip joints

	Type of Motion	F	E	ABD	ADD	IR	ER
Dx	Active	130 °	**20 °**	45 °	10 °	30 °	45 °
	Passive	135 °	20 °	50 °	15 °	35 °	50 °
Sin	Active	120 °	**8 °**	**30 °**	**5 °**	30 °	**35 °**
	Passive	120 °	**10 °**	**35 °**	10 °	35 °	**40 °**

2. Knee joints

	Type of Motion	F	E
Dx	Active	130 °	0 °
	Passive	135 °	0 °
Sin	Active	**120 °**	0 °
	Passive	**125 °**	0 °

3. Ankle joints

	Type of Motion	Dorsal F	Plantar F	Inversion	Eversion
Dx	Active	20 °	45 °	35 °	15 °
	Passive	25 °	**40 °**	40 °	20 °
Sin	Active	**25 °**	**40 °**	**30 °**	**10 °**

	Passive	**30 °**	45 °	**35 °**	15 °

4. Metatarsophalangeal joints:

		Type of Motion	**F**	**E**
Dx	1st digit	Active	45 °	30 °
		Passive	50 °	30 °
	2nd digit	Active	40 °	30 °
		Passive	35 °	**30 °**
	3rd digit	Active	30 °	30 °
		Passive	35 °	40 °
	4th digit	Active	20 °	40 °
		Passive	**45°**	45 °
	5th digit	Active	35 °	60 °
		Passive	45 °	65 °

Sin	1st digit	Active	45 °	30 °
		Passive	45 °	30 °
	2nd digit	Active	40 °	30 °
		Passive	40 °	25 °
	3rd digit	Active	40 °	25 °
		Passive	40 °	25 °
	4th digit	Active	40 °	30 °
		Passive	45 °	35 °
	5th digit	Active	40 °	30 °

		Passive	50 °	40 °

5. Inter-phalangeal joints

		Type of Motion	**F**	**E**
Dx	1st digit	Active	40 °	80 °
		Passive	40 °	**80** °
	2nd digit	Active	55 °	0 °
		Passive	60 °	5 °
	3rd digit	Active	60 °	0 °
		Passive	**70** °	5 °
	4th digit	Active	60 °	0 °
		Passive	60 °	**15** °
	5th digit	Active	60 °	0 °
		Passive	70 °	5 °

Sin	1st digit	Active	40 °	90 °
		Passive	40 °	90 °
	2nd digit	Active	55 °	0 °
		Passive	60 °	5 °
	3rd digit	Active	60 °	0 °
		Passive	60 °	10 °
	4th digit	Active	60 °	0 °
		Passive	65 °	5 °

	5th digit	Active	60 °	0 °
		Passive	**60** °	0 °

Table 10 - Final examination of active and passive ROM of lower extremity.

- **Muscle length testing.**

Performed according to Janda (25)

Shortness grade scale: **0** - No shortness, **1**- moderate shortness, **2** - marked shortness

Examined Muscle	Dexter	Sinister
Iliopsoas	1	**1**
Rectus Femoris	1	**0**
Tensor Fascia Latae	1	**2**
Sartorius	0	0
Hip Adductors	0	0
Gluteus Maximus	0	0
Gluteus Minimus	0	0
Gluteus Medius	0	0
Piriformis	0	0
Hamstrings	0	1
Gastrocnemius	1	0
Soleus	0	0
Tibialis Anterior	0	0

Table 11 – Final examination of muscle shortness according to Janda.

- **Manual muscle strength testing (MMT).**

Performed according to Kendall (33)

Kendall MMT Grading scale: **Zero grade (0)** – no contraction palpable, **Trace grade (1)** – visible or palpable contraction, **Poor grade (2)** – ability of muscle to move in horizontal plane without force of gravity **Fair grade (3)** – muscle can hold test position against gravity only, **Good grade (4)** - ability to resist against moderate pressure throughout entire ROM range, **Normal grade (5)** – Holds test position against strong pressure.

Note* sub-classifications of key grades with + or – values are applied according to gradations in muscle strengths and judgment of examiner's feedback. Strength testing was performed according to Kendall's suggested order from 1. Supine, 2. Side-lying, 3. Prone, 4. Sitting.

Muscle / Group	Grades for Right side	Painful Arc	Grades for Left side	Painful Arc
Toe Extensors	5	No	5	No
Toe Flexors	4+	No	4+	No
Tibialis Anterior	5	No	**5**	No
Tibialis Posterior	5	No	5	No
Peroneals	**5**	No	**4**	**No**
Tensor Fascia Latae	4+	**Yes**	5	No
Sartorius	5	No	5	No
Iliopsoas	5	No	5	No
Gluteus Medius	5	No	**4+**	No
Gluteus Minimus	4+	No	4+	No
Hip Adductors	5	No	5	No
Gastrocnemius	5	No	**5**	No
Soleus	5	No	4-	No
Hamstrings	5	No	5	No
Gluteus Maximus	4	No	**4+**	No
Quadriceps	5	No	**5**	**Yes**
Piriformis	**4+**	No	4+	No
Medial Hip Rotators	5	No	5	No
Hip flexors (group test)	5	No	5	No

Table 12 – Final results for strength testing of lower extremity according to Kendall.

- **Joint play**

Performed according to Lewitt (3)

Key to examination tables is as follows:

0 - Indicates no blockage at the joint and reaching of physiological barrier

X - Restricted/ hard barrier

XX - Restricted and painful barrier

8. Proximal and distal phalanges of right lower extremity					
	I digit	II digit	III digit	IV digit	V digit
Dorsal	0	0	0	0	0
Ventral	0	0	0	0	0
Latero-lateral	0	0	0	0	0
Rotation (*Rx*)	0	0	0	0	0
9. Proximal and distal phalanges of left lower extremity					
Dorsal	0	0	0	0	0
Ventral	0	0	0	0	0
Latero-lateral	0	0	0	0	0
Rotation (*Rx*)	0	0	0	0	0
10. Metatarsal-phalangeal joints of right lower extremity					
	I digit	II digit	III digit	IV digit	V digit
Dorso-ventral	0	X	X	0	0
Rotation (*Rx*)	0	0	0	0	0
11. Metatarsal-phalangeal joints of left lower extremity					
Dorso-ventral	0	X	X	0	0
Rotation (*Rx*)	0	0	0	0	0
12. Lisfranc joint					
	Right LE			Left LE	
Dorsal	0			0	
Plantar	0			0	
13. Chopart's joint					
	Right LE			Left LE	
Dorsal	0			0	
Plantar	0			0	

14. Talocrural joint			
	Right LE		Left LE
Ventral	0		0
Plantar	0		0

Table 13 - Final joint play examination of the foot and ankle of lower extremity.

4. Tibiofibular joint (head of fibula)		
	Right LE	Left LE
Ventral	contraindicated post-surgery	contraindicated post-surgery
Dorsal	contraindicated post-surgery	contraindicated post-surgery
5. Knee joint		
	Right LE	Left LE
Medial	0	0
Lateral	0	0
Anterior	0	**0**
Posterior	0	**0**
6. Patella		
	Right LE	Left LE
Ventral	0	X
Caudal	0	**X**
Later-lateral	0	0
Circumduction	0	**0**

Table 14 – Final examination of joint play of lower extremity continued.

3.7. Evaluation of the Effect of Therapy

Prior to discussing the effects of the therapy, it is important to highlight the main short-term goals that were outlined at the outset in M.H.'s physiotherapy plan.

The main aims were to prevent chronic knee stiffness by mobilizing the knee early on and reaching a flexion position of at least 90°. Strengthening knee stabilizing muscles,

specifically the quadriceps muscle. Scientific literature in exercise rehabilitation reveals the Vastus Medialis Oblique (VMO), just above and to the inside of the kneecap. The VMO is incredibly important in eliminating anterior knee pain while supporting it. Increasing strength of thigh and calf muscles correlates directly to increasing muscle mass in those regions. Strengthening builds up muscle and vice versa, building muscle increases strength. Thus, another aim is to view improvements in anthropometric measurements in those areas. Fine tuning muscle performances cannot be executed without adjusting hypertonic and short muscles of the LE, a final aim of our therapy.

To summarize the data obtained in the final kinesiological examination, I will provide a quick guide as to the parameters that have changed the most due to therapy. Listed below are the particular results with the most significance to this case study.

Hypertonicity in left hip flexors, knee extensors and ankle flexors has been reduced. Patients feels a sense of release.

Muscle strength has improved in key muscles of the lower extremity, at least by one grade on the Kendall scale, the key muscle being the Quadriceps. This will contribute to recovery of knee joint stability.

Muscle trophy of the left thigh and calf has increased by 2cm restoring lost muscle mass.

Range of Motion of the knee has been restored beyond the initial goal of 90° to a maximum of 120°.

Joint play reveals improved dynamics in the patella of the knee in almost all directions, and a release in the Anterior and posterior glide of the tibia upon the femur.

Comparative analysis in therapeutic data is highlighted in the tables below.

Tables of the main changes after therapeutic implementation.

	Circumference (cm)	
	07.01.2014	**20.01.2014**
Knee joint	17	15
Calf	15	16
Thigh	40	43

Evaluation of Anthropometry of the left **LE**

Table 15 - Comparison of anthropometric data

Evaluation of ROM of the left **LE**

Table 16 - Main improvements in ROM

	07.01.2014		**20.01.2014**	
Movement	**Active**	**Passive**	**Active**	**Passive**
Hip ER	30°	35°	35°	40°
Knee F	35°	40°	120°	125°
Ankle DF	20°	25°	25°	30°
Ankle inversion	25°	30°	30°	35°

Evaluation of muscle length in left **LE**

Table 17 - Evaluation of muscle strength tests using Janda's grading system

	07.01.2014	**20.01.2014**
Iliopsoas	3	1
Rectus femoris	1	0
Tensor fascia Latae	1	2
Gastrocnemius	1	0

Soleus	1	0

Evaluation of muscle strength tests of the left **LE**

Table 18 - Evaluation of muscle strength tests using Kendal's grading system

	07.01.2014	**20.01.2014**
Gluteus medius	4-	5
Gluteus maximus	3+	4+
Quadriceps	4-	5
Gastrocnemius	4-	5
Tibialis anterior	4+	5

Evaluation of joint play in left **LE**

Table 19 - Evaluation of restriction in joint play of lower extremity

	07.01.2014	**20.01.2014**
Knee Anterior shift	Restricted	No restriction
Knee Posterior shift	Restricted	No restriction
Patella-Caudal	Very restricted	Slight restriction
Patella- Circumduction	Restricted	No restriction

3.7.1. Continuation of Long Term Therapy Proposal.

The patient has progressed markedly in many physiotherapeutic parameters, however care and rehabilitation must not stop here. To put this study into perspective, I must emphasize that as a therapist I have actively treated the patient in a sub-acute phase and in an out-patient setting for a duration of 6 sessions ranging for 1-1.5 hours. The patient also engaged in auto-therapy at home increasing the tally of "rehabilitative exercise" time.

Implementation of the long-term physiotherapeutic plan must include the following components, bearing in mind that optimal function of the knee is typically regained after a year:

Maintain and improve ROM of the knee; initiate a standard of care to manage any arising symptoms such as pain, swelling and edema.

Once the patient returns to full weight-bearing status, initiate sensomotoric exercises for enhanced proprioception. This is as important for prevention of future injury as it is for stability of the knee and other joint structures of the lower extremity.

Gait re-education to prevent limping and ensure fluidity, balance and control within the gait cycle.

Continue strengthening exercises for lower extremity until 5/5 strength is restored in every prime mover muscle.

3.7.2. Prognosis.

Judging by the type of fracture, age of patient, and compliance with therapy, patient M.H. shows solid progress in her recovery and I would comment that she has a favorable prognosis. There are many factors making her condition highly amenable to recovery. She led an active lifestyle prior to surgery, her level of motivation towards recovery is very high, and she is diligent at engaging in auto-therapy methodically and without an apathetic attitude. She had an uncanny ability to follow all the exercises shown to her as per instructions. From an ADL standpoint, her occupation does not place her in a high-impact, labor- ridden environment which will not interfere negatively with any progress in rehabilitation. Given the milestones achieved within a rather short period of therapy, there are no impediments for full recovery in the patient's health.

4 CONCLUSION

I have treated patient M.H. who required rehabilitation for sustaining a compression injury to her left lateral tibial plateau for a total of six therapy sessions. I have implemented physiotherapeutic techniques and approaches borrowing from manipulative therapy, PNF techniques, soft tissue techniques, and strengthening exercises with the objective of restoring mobility and stability to her knee joint complex and increasing active ROM flexion for at least 90°.

The therapeutic outcome indicates recovery progress in all key goals set at the beginning of this case study. ROM of the knee has surpassed our benchmark value of 90° by an additional 30°.

The patient has regained enough strength in her left lower extremity to move from Non-weight bearing status (NWB) to 30% loading.

Muscle trophy to her left thigh, which presented initially with significant hypotrophy, has been partially restored.

Conclusively, the rehabilitative process has been successful when evaluated against our short-term physiotherapy goals. The only limitation to making further “leaps” in recovery is the limited number of therapy sessions spent with the patient.

From looking at the evaluation data in the comparative tables, I am certain that implementing the therapeutic approaches used in this study can aid the recovery of other patients presenting with a similar clinical picture as patient M.H.

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6 SUPPLEMENTS

6.1. List of Tables.

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Figure 10: Classes IV, V, VI of tibial plateau fractures according to Schatzker.

6.3. List of Abbreviations.

AAPO = Arthroscopically Assisted Percutaneous Osteosynthesis

ABD = Abduction

ACL = Anterior Cruciate Ligament

ADD = Adduction

ADL = Activities of Daily Living

BP = Blood Pressure

BPM = Beats Per Minute

CT = Computed Tomography

E = Extension

ER = External Rotation

F = Flexion

IR = Internal Rotation

LCL = Lateral Collateral Ligament

LE = Lower Extremity

MCL = Medial Collateral Ligament

MRI = Magnetic resonance Imaging

PCL = Posterior Collateral Ligament

PIR = Post – Isometric Relaxation

RHB = Rehabilitation

ROM = Range Of Motion

TrP = Tigger Point

VMO = Vastus Medialis Oblique

6.4. Patient Consent Form.

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 souhlasím s vyšetřením a následnou terapií. Dávám souhlas k nahlížení do mé dokumentace osobou získávající způsobilost k výkonu zdravotnického povolání (dále-odborný pracovník) v rámci praktické výuky a s uveřejněním výsledků terapie v rámci bakalářské práce na FTVS UK. Osobní data v této studii nebudou uvedena.

Dnešním dnem jsem byla oslovena odborným pracovníkem ke spolupráci při mé léčbě pro zpracování jeho bakalářské práce, byla jsem poučena o plánovaném vyšetření a následné terapii a seznámena s časovými souvislostmi, postupy i formou sledování – neinvazivní. Prohlašuji a svým níže uvedeným podpisem stvrzuji, 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 jsem dostala řádnou odpověď.

Prohlašuji, že jsem shora uvedenému poučení plně rozuměla a výslovně souhlasím s provedením vyšetření a následnou terapií.

Souhlasím také s tím, aby odborný pracovník mohl nahlížet do mé zdravotní dokumentace a s uveřejněním výsledků terapie v rámci jeho studie.

Datum: .....

Osoba, která provedla poučení: .....

Podpis osoby, která provedla poučení: .....

Vlastnoruční podpis pacientky: .....

6.5. Ethics Board Committee Approval.

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José Martího 31, 162 52 Praha 6-Veleslavín
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Application for Ethics Board Review

Undergraduate Research involving human subjects

Project title: Tibial Plateau Fracture and Physiotherapy

Nature of the research project: undergraduate research, Bachelor of physiotherapy thesis

Author (chief investigator): Bettule Hamed (Bsc. Student)

Supervisor (in case of student research): PhDr. Pavlu Dagmar

Research Project Description

The topic of research will be regarding the recovery of a middle-aged patient from a tibial plateau fracture due to injury. The patient will be *evaluated* and *rehabilitated* from both a physiotherapeutic, kinesiological, and physiological standpoint at Centrum Lečby Pohyboveho Aparatu (C.L.P.A.), under the supervision of a qualified physiotherapist.
Guaranteed safety to be judged by experts: no invasive procedures will be implemented at any point
Ethical aspects of the research: Patient safety is not compromised and the highest safety standards will be adhered to. Patient will remain anonymous and all personal data will not be published.
Informed consent (please view attached)

Date: 06/01/2014 Author's signature:

Faculty of Physical Education and Sport, Charles University in Prague
ETHICS BOARD REVIEW

Ethics Board members: Doc. MUDr. Staša Bartůňková, CSc.
Prof. Ing. Václav Bunc, CSc.
Prof. PhDr. Pavel Slepička, DrSc.
Doc. MUDr. Jan Heller, CSc.

The Ethics Board at the Faculty of Physical Education and Sport, Charles University, approved the research project.
Approval number: 098/2014
Date: 24.2.2014

The Ethics Board at the Faculty of Physical Education and Sport, Charles University, reviewed the submitted research project and **found no contradictions with valid principles**, regulations and international guidelines for biomedical research involving human subjects.

The chief investigator of the project met the necessary requirements for receiving the Ethics Board approval.

Official school stamp
UNIVERZITA KARLOVA v Praze
Fakulta tělesné výchovy a sportu
José Martího 31, 162 52, Praha 6
1

Signature, REB Chairman