CHARLES UNIVERSITY

FACULTY OF PHYSICAL EDUCATION AND SPORTS

Physiotherapy Department

Case study of physiotherapeutic treatment of a patient after Total Knee Replacement

Bachelor's thesis

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Prague, 05/2020

Declaration

I declare that this thesis is entirely my own. The theoretical information has been sourced using secondary methods of research, therefore the literature has been referenced at the end of this document. The practical information (examinations and therapeutic procedures) practiced are based on knowledge taught by professors from FTVS Charles University (Prague),

I declare the patient was made aware of all the practical procedures and was in full agreement.

In Prague: May 2020 Author: Belinda Hlomayi

Acknowledgements

I would like to give thanks to all my professors for being part of my journey: teaching, correcting, and most importantly pushing me to aim higher and do better. I would like to greatly appreciate my work's supervisor, *doc. PaedDr. Dagmar Pavlu* for her patience and dedication to guide me throughout this entire process. Thank you all.

Abstract

Title: Case study of physiotherapeutic treatment of patient after total knee replacement.

Aim of thesis: the aim of this thesis begins with an understanding of the human knee anatomically, followed by how its anatomy becomes functional by exploring the biomechanics and kinesiology aspects of the knee. This paper will further discuss on what leads to total knee replacement. Practically the aim of this thesis is to bring the knowledge acquired theoretically into practice as it explores the treatment process after total knee replacement surgery.

Clinical findings: patient is a 57 year old man who was two days after total knee replacement surgery of the left knee. The need for replacement was due to bilateral gonarthrosis. He was able to walk with crutches with partial loading on the left leg. Patient present with very low mobility in the left knee and pain (normal two day after surgery).

Methods: all methods applied through the therapy where based on literature or lectures from Charles University (Prague) Faculty of Physical Education and Sport. The methods mainly consisted of: soft tissue techniques, Post Isometric Relaxation, stretching and active strengthening exercises. The active exercise had variety and were tailored to the patient's abilities. The patient additionally received other physiotherapeutic methods from other professionals in the hospital such as cryotherapy and hydrotherapy.

Result: after the 10 sessions of physical therapy with the patient, he was very functionally independent. He increased range of motion in the left knee and was free from pain.

Conclusion: the therapies performed on the patient showed to be very effective.

Keywords: total knee replacement, knee joint, weakness, limitation.

Abstraktní

Název: Případová studie fyzioterapeutické léčby pacienta po totální náhradě kolene.

Cíl práce: Cílem této práce je anatomické pochopení lidského kolena, následuje funkční anatomie člověka zkoumáním biomechanických a kineziologických aspektů kolena. Tento dokument bude dále diskutovat o tom, co vede k úplné výměně kolen. Prakticky je cílem této práce uvést teoreticky získané poznatky do praxe, protože zkoumá léčebný proces po totální náhradě kolenního kloubu.

Klinické nálezy: pacient je 57 let starý muž, který byl dva dny po totální náhradě kolenního kloubu levého kolene. Potřeba nahrazení byla způsobena oboustrannou gonartrózou. Dokázal chodit s berlemi s částečným zatížením na levé noze. Pacient má velmi nízkou pohyblivost v levém koleni a bolesti (normální dva dny po operaci).

Metody: všechny metody aplikované při terapii, kde na základě literatury nebo přednášek z Fakulty tělesné výchovy a sportu UK (Praha). Metody se skládaly hlavně z: technik měkké tkáně, postizometrické relaxace, protahovacích a aktivních posilovacích cvičení. Aktivní cvičení mělo rozmanitost a bylo přizpůsobeno pacientovým schopnostem. Pacient navíc obdržel další fyzioterapeutické metody od jiných odborníků v nemocnici, jako je kryoterapie a vodoléčba.

Výsledek: po 10 lekcích fyzické terapie s pacientem byl velmi funkčně nezávislý. Zvýšil rozsah pohybu v levém koleni a byl bez bolesti.

Závěr: terapie provedené na pacientovi se ukázaly jako velmi účinné.

Klíčová slova: totální náhrada kolene, kolenní kloub, slabost, omezení.

Dedication

I would like to dedicate this bachelor's thesis to my Father and Mother. This is yet another symbol of your never ending support in my life (in all aspects). Thank you for being there for me when I need you the most. I love you both and I am very grateful to have you.

I would also like to dedicate this work to my sisters. Through thick and thin: you have constantly encouraged me, helped me hold my head high, laughed with me through the pain, celebrated with me on the highs. You are all my source of inspiration. I love you.

Table of Contents

INTRODUCTION:

This thesis is based on a patient that underwent a total knee replacement and was treated over the course of 10 days as an inpatient. The paper will focus on uncovering his rehabilitation process through physiotherapeutic methods.

The thesis is divided into 3 parts. The first part will look into the anatomy of the knee, and how it functions in relation to Biomechanics and integrates from a kinesiology point of view to the body as a whole. The second part of this thesis will discuss on possible pathologies or diseases found in the knee joint; their aetiologies, effects and possible treatment(s). This part will also highlight on knee replacements: treatment options, and possible complications.

Lastly the third part of the thesis will contain the practical side to this research. Meaning it will be focused directly on the ten day treatment procedure of the patient that underwent the total knee replacement. It contains information on the state of the patient prior to the physical therapy treatments, the therapy sessions done and lastly the state of the patient post physiotherapeutic treatments. From this information, there will be an evaluation of the effectiveness of performed therapies as the patient's pre and post treatment states are compared.

1. Theoretical Chapter

1.1 Anatomy of the Knee Joint

The knee joint is a synovial hinge joint. It is the largest and is considered as one of the most complicated joints in the body, as it is supported functionally and structurally only by muscles and ligaments. As it directly follows our base of support, the knee joint commonly faces a great deal of stresses and strains making it very susceptible to injuries [45].

1.1.1 Joint Articulations

This joint is composed of 3 bones: the Femur, Patella and Tibia. They articulate by two joints the Patellofemoral joint and Tibiofemoral joint. The patellofemoral joint is the articulation of the facies articularis of the patella to the femur: the medial facet of the patella articulates with the medial condyle of femur and the lateral facet with the lateral condyle. Meanwhile the tibiofemoral joint is the articulation of the femur and the tibia: the lateral and medial condyles of the femur rest on the tibia plateau found on the superior surface of the lateral and medial condyles of the tibia. These joints are covered in the same capsule: the synovial fluid encompasses the tibia, patella and femur. It has the purpose of lubricating and giving nutrients to the joint [44].

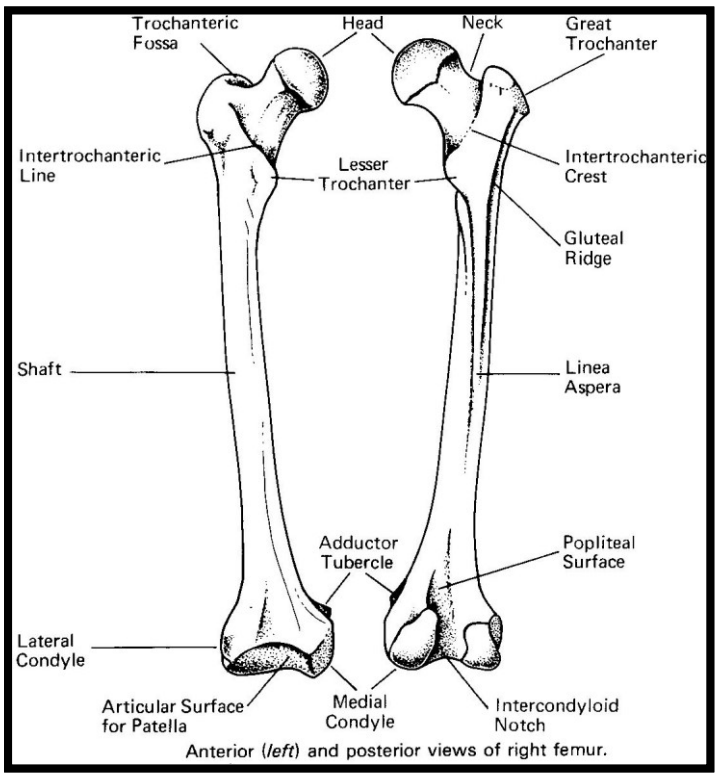


Image No.1: Showing Femur Bone [60]

Femurs are the longest bone in the human body. The femurs are the only bones in the upper leg and they converge medially towards the knees from their pelvic articulation. This angle of convergence defines the femoral-tibial angle. The femoral-tibial angle is different between men and women: women have a more converging degree due to having wider pelvic bones. The more the femur converges, it causes *genu valgum* and the less it converges it causes *genu varum* [34] [64].

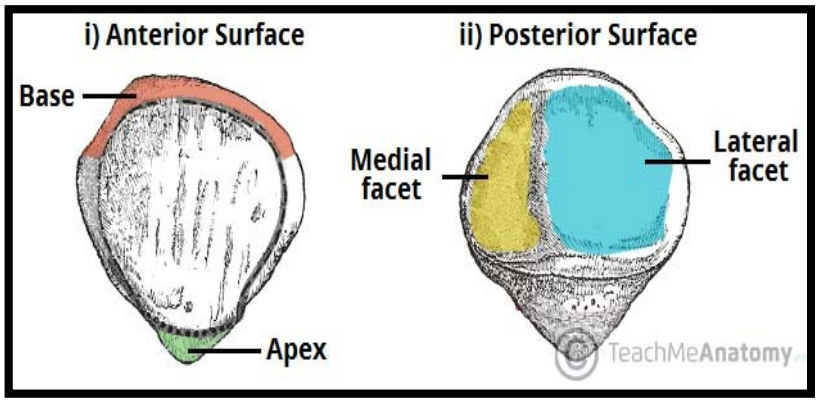


Image No.2: Showing anterior and posterior aspects of patella bone [1].

The patella is the largest sesamoid bone in the human body: it is a round-triangular and flat bone. Patella is quite freely movable but is kept in place during flexion by the horizontal fibres of the vastus medialis and the prominence of the lateral condyle of the femur. The patella dislocates mainly laterally, and can be easily fractured due to its exposure [1].

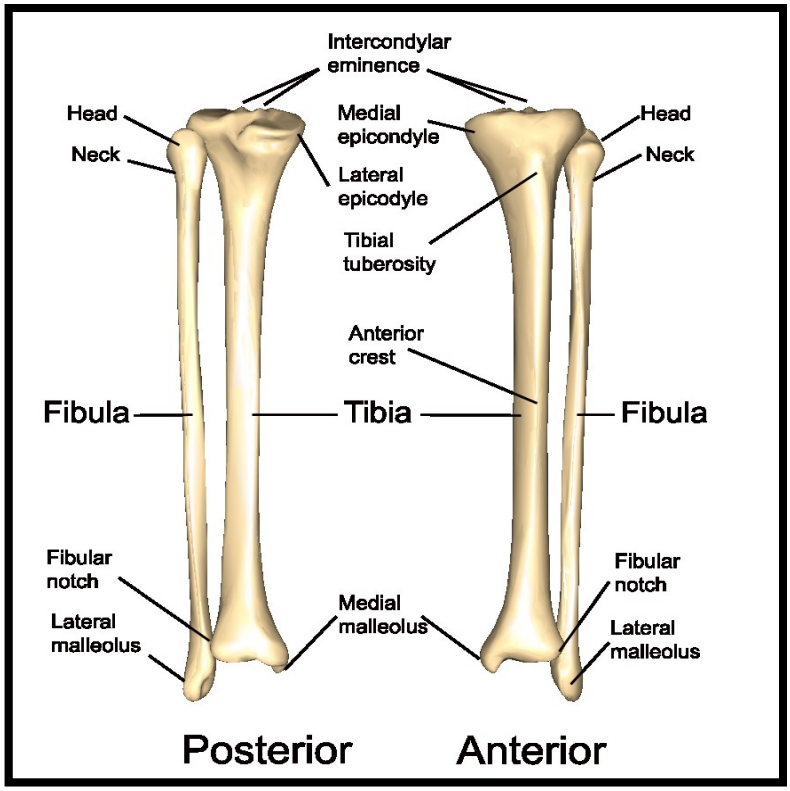


Image No.3: showing the femur and tibia bones [75].

The tibia is the second largest bone in body and the largest in the lower leg, found medially/closer to the midline of the body. It is the connection between the knee and ankle joints. The tibia is very located close to the skin, one can feel the bone when palpating the shin (anterior side of lower leg). This bone is key to weight-bearing. [32].

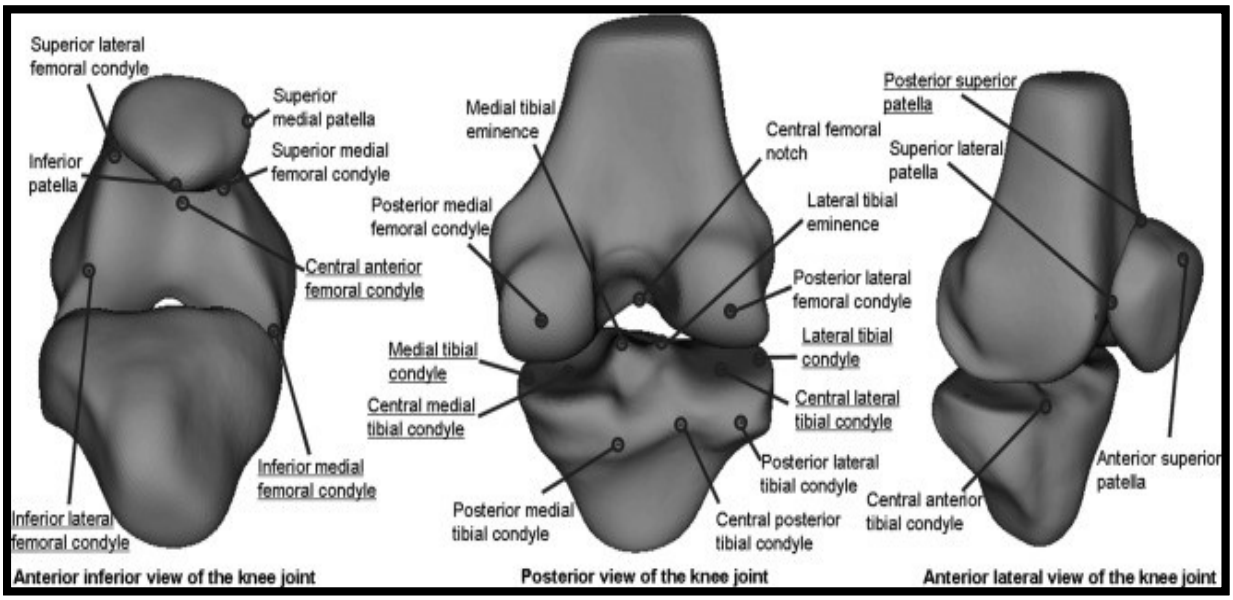


Image No.4: showing the anterior, posterior and lateral view of the knee joint articulations [77].

1.1.2 Joint Ligaments

There are two types of ligaments supporting the knee joint, the Cruciate and Collateral ligaments. Cruciate ligaments are found within the joint hence they can be referred to as Intracapsular Ligaments. One of the ligaments originates from anterior side of the medial condyle of the femur and attaches to the posterior intercondylar surface of the tibia. Meanwhile the other ligament originates from the posterior side of the lateral condyle of the femur and attaches to the anterior intercondylar surface of the tibia. Due to their attachments on the tibia, they are named the Posterior Cruciate Ligament and the Anterior Cruciate Ligament respectively. They are named cruciate ligaments as they obliquely cross each other. The function of these ligaments collectively is to stabilize the knee in the sagital plane. The ACL* prevents the femur from displacing posteriorly to tibia or the tibia anteriorly to femur. On the other hand the PCL* prevents the femur from displacing anteriorly to the tibia or the tibia posteriorly to the femur. Hence the ACL tightens during extension and PCL during flexion. It is more likely for there to be ACL injuries in comparison to PCL.

The collateral ligaments in our knee joint. These are located medially and laterally to the knee: the Medial Collateral Ligament (tibial collateral) is attached from the medial condyle of the femur to the medial condyle of the tibia. Meanwhile the Lateral Collateral Ligament (fibular collateral) originates from the lateral condyle of the femur and attaches to the fibular head. The MCL* is also attached to medial fibres of the meniscus therefore when stressed it could also damage the meniscus, while the LCL* has no relation to the meniscus. The function of this meniscus is to give stability to the knee in frontal plane. The MCL provides stability of the knee on the medial side and also prevents too much motion of the lateral side when blows occur in the knee. The LCL also provides medial stability, it tightens during extension. The LCL is very strong and common to injury.

Another ligament found in the knee joint is the Patella ligament. It continues form the quadriceps tendon and attaches to the tibial tuberosity. Patella ligament's function is to keep the patella in position and to assist the knee in flexion. [45] [76].

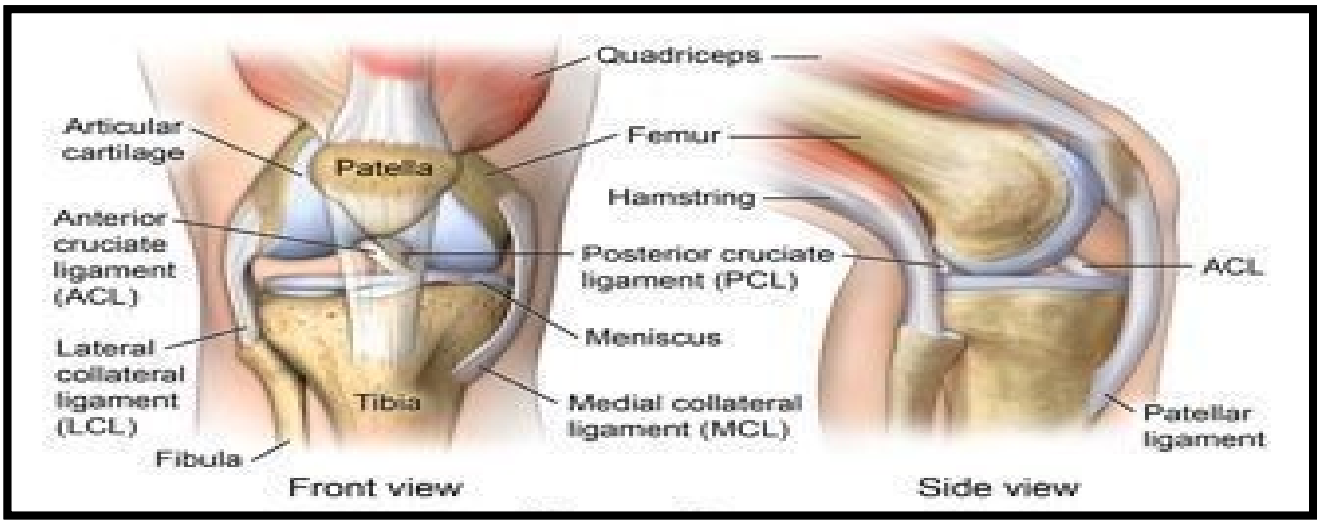


Image No.5: knee ligaments in anterior and lateral view [27].

1.1.3 The Meniscus of the Knee Joint

Meniscus is fibrocartilage located on the superior surface of the tibia in a two half-moon wedged shape. We each have the lateral and medial meniscus: the lateral meniscus is the thicker one of the two and its proximal surface is concave.

The purpose of the meniscus is to be a shock absorber, and also it structurally it deepens the flat joint surface. Between the medial and lateral meniscus, the medial is more at risk of damage, this is due to its attachment to the medial collateral ligament. The attachment to adjacent structures make it stiffer. When injured the meniscus is hard to heal because the blood supply is not so rich additionally its structural complexity makes it harder to treat [21].

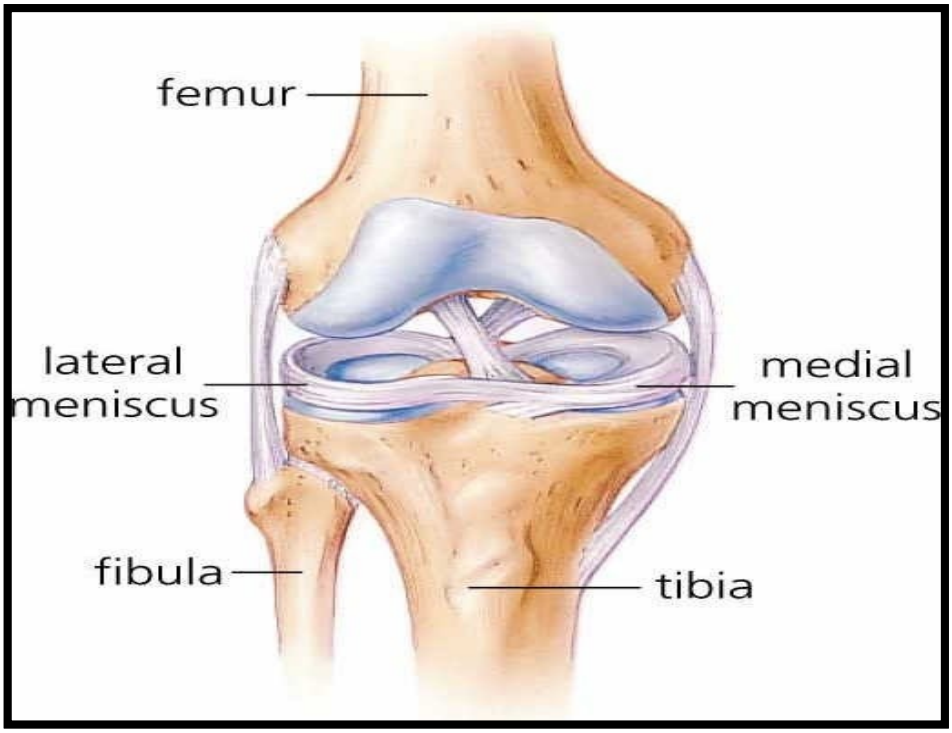


Image No.6: Lateral and Medial meniscus.[8].

1.1.4 Joint Bursa(s)

The purpose of Bursa is to reduce friction. The knee joint is associated with approximately 13 bursae': it is convenient to have such a large number in Bursa's because this joint consists of many tendons located all around. These tendons have tendency to have a vertical line of pull against bony structures or other tendons which causes friction. The Bursa's are classified according to their location in the knee. [9].

Anterior	***Posterior***	***Lateral***	***Medial***
Subcutaneous Pre-patellar Deep Infrapatellar Subcutaneous Infrapatellar Suprapatellar	Gastrocnemius (for medial head and lateral head) Popliteal Semimembranosus Biceps	Iliotibial Fibular collateral ligament	Anserine

Table No.1: The list of most frequently discussed bursa of the knee joint. [29].

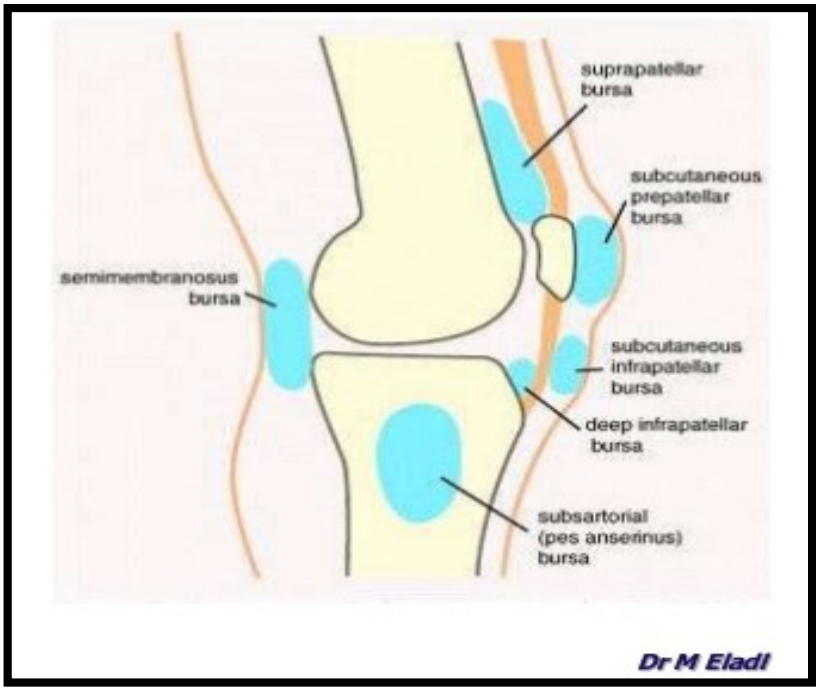


Image No.7: Positions of the major bursae of the knee (lateral view). [18]

1.1.4 Innervation of the Knee

The knee is innervated or associated by three nerves: Femoral, Sciatic and Obturator nerves. They either help to function the muscles affecting the knee joints, innervate the ligaments, fibrous capsule and/or the synovial membrane. This makes the nerves either motoric or sensory or both. The sensory fibres in the knee have an analgesic effect, they try to diffuse rather than localise the pain.

Femoral nerve – it originates from the Lumbar Plexus from the roots L2 – L4. Motoric function of it is to activate knee extensors and the knee flexor sartorious. Sensory function of it is to innervate the anteromedial thigh. Injury to the femoral nerve: motor loss causes paralysis of quadriceps Femoris and Sartorius making it hard to walk. Sensory loss causes loss of sensation on anterior and medial aspect of thigh, medial aspect of leg and foot till head 1st MT.

Sciatic nerve – it originates from the Lumbosacral Plexus from the roots L4 – S3. Motoric function of it is to activate knee flexors and the hamstring part of the adductor magnus muscle. It has no sensory relations to the knee. Injury to sciatic nerve leads to foot drop (gait abnormality in which the forefoot cannot be lifted off the ground due to paralysis of the anterior side of leg, causing failure of dorsiflexion).

Obturator nerve – it originates from the Lumbar plexus nerve from the roots L2 – L4. Motoric function of it is to activate all muscles of the medial compartment of the thigh. It provides articular branches to hip and knee joints. The anterior branch of the obturator nerve supplies to the cutaneous of the medial thigh and above medial knee Injury to the obturator nerve will cause motor loss leading to paralysis of adductor muscles of thigh, and sensory loss on the skin over the lower medial aspect of thigh. [70] [17] [30]

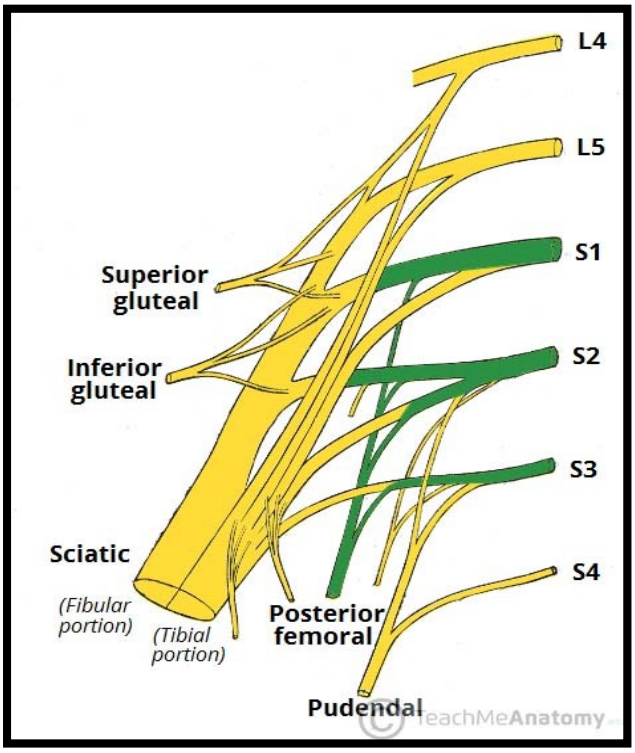


Image No.8: The Sacral Plexus. [15]

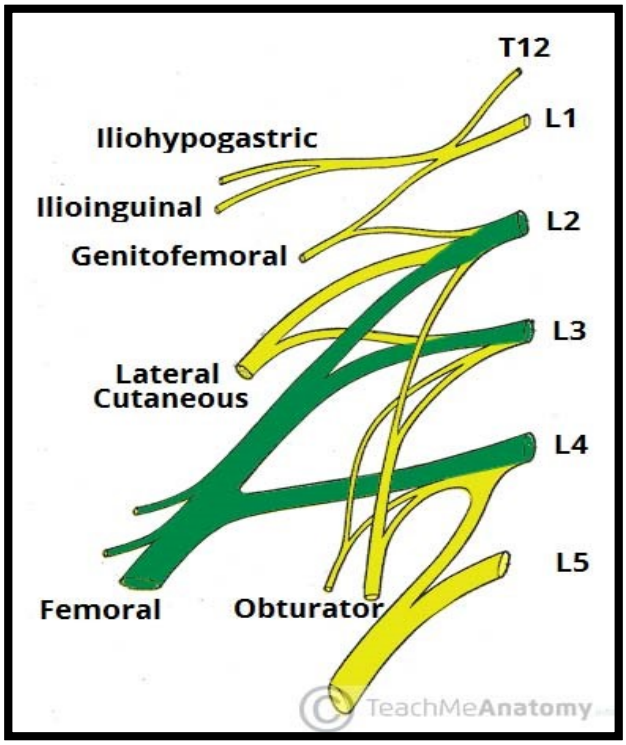


Image No.9: The Sacral Plexus. [15]

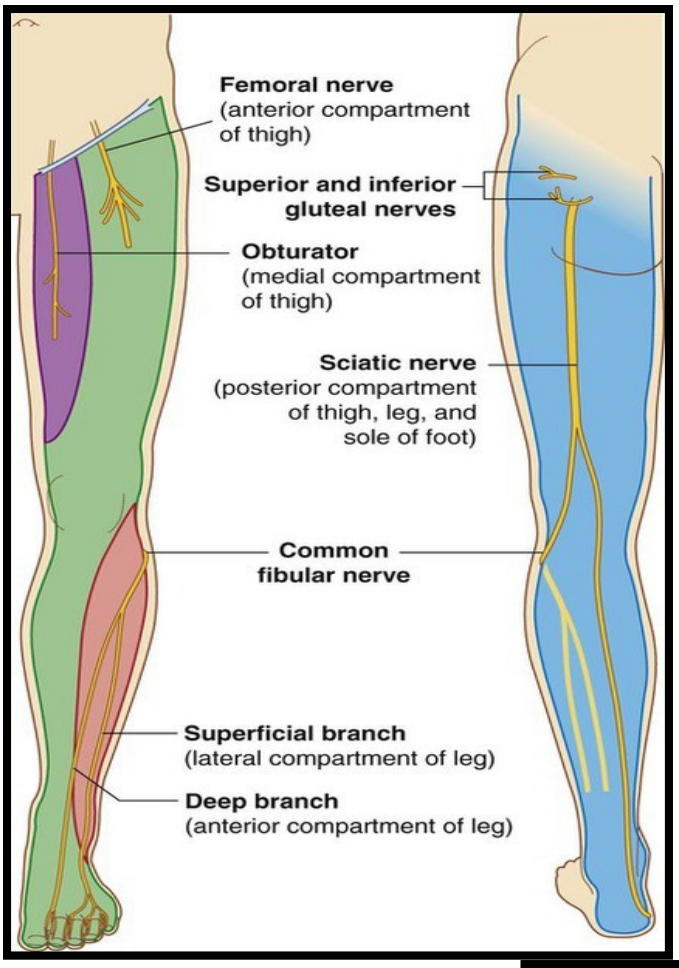


Image No.10: The nerve pathways of the main nerves supplying the lower extremity. [62]

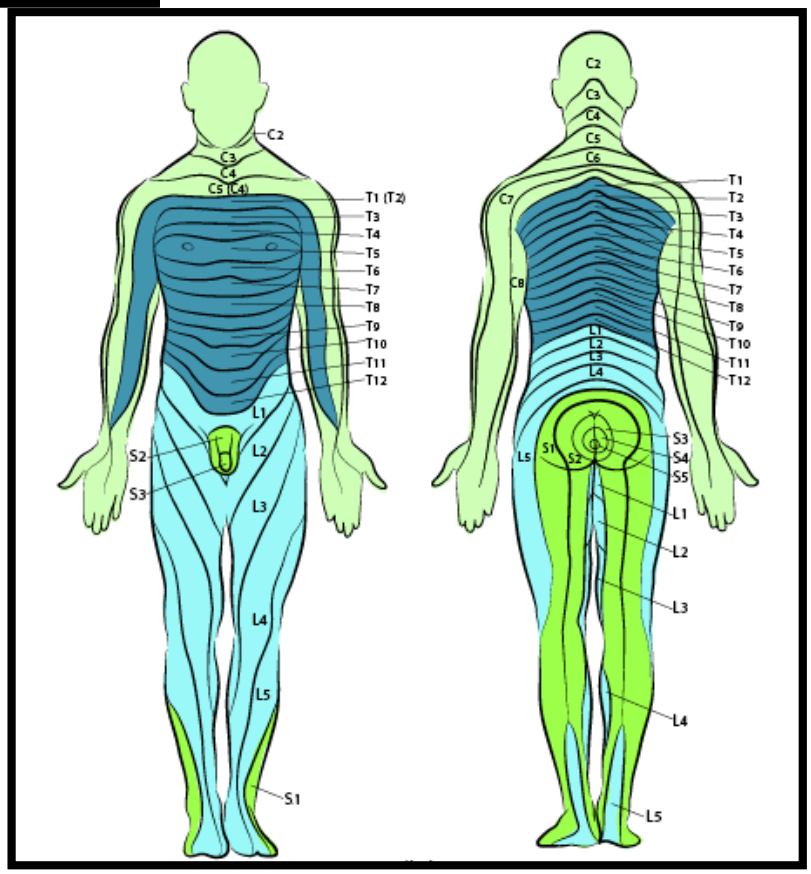


Image No.11: Dermatome map of the human body (anterior and posterior view). [74]

1.1.6 Muscles working at the knee Joint

The Knee joint brought to function by groups of muscles:

a) The anterior group – consists of the quadriceps femoris muscles (rectus femoris, vastus medialis, vastus lateralis, and vastus intermedialis) and Sartorius.

Muscle	**Origin**	**Insertion**	**Action**	**Innervation**
Vastus Lateralis	Greater trochanter and lateral lip of linea aspera	Patella – via the quadriceps Femoris tendon	Extends the knee joint and stabilises the patella	Femoral Nerve
Vastus Intermedius	Anterior and lateral surfaces of femoral shaft	Patella – via the quadriceps Femoris tendon	Extends the knee joint and stabilises the patella	Femoral Nerve
Vastus Medialis	Intertrochanteric line and medial lip of linea aspera.	Patella – via the quadriceps Femoris tendon	Extends the knee joint and stabilises the patella well due to horizontal fibres at the distal end	Femoral Nerve
Rectus Femoris	Ilium just superior to the acetabulum	Patella – via the quadriceps Femoris tendon	2 joint muscle (connects to hip and knee). Extends knee joint. Flexes hip	Femoral Nerve
Sartorius	ASIS*	Superior, medial surface of Tibia	Flexor of the knee joint. (at hip joint it is a flexor, abductor and lateral rotator)	Femoral Nerve

Table No.2: Muscles in the anterior compartment of the thigh working on the knee joint. [35]

b) The posterior group – consist of the hamstrings (semimembranosus, semitendinosus, biceps Femoris and popliteus)

Muscle	Origin	Insertion	Action	Innervation
Biceps Femoris	Long head- ischial tuberosity of the pelvis. Short head- linea aspera posterior surface of femur	The two heads form a tendon inserting onto the head of fibula.	Main function is flexion at knee. Also extends the hip. Laterally rotates the hip and knee.	Long head- tibial part of sciatic nerve. Short head- common fibular part of sciatic nerve.
Semitendinosus	Ischial tuberosity of pelvis	Medial surface of tibia	Flexion of leg at knee joint. Medially rotates the leg at hip and knee joints	Tibial part of sciatic nerve
Semimembranosus	Ischial tuberosity (above the others)	Medial condyle of tibia.	Flexion of the leg at the knee. Extension of thigh at hip. Medially rotates the leg at hip and knee joints	Tibial part of Sciatic nerve.
Popliteus	Femur and posterior horn of lateral meniscus	Posterior surface of proximal tibia.	Dorsal knee stability, and unlocks the knee joint.	Tibial part of sciatic nerve.

Table No.3: Muscles in the posterior compartment of the thigh working on the knee joint. [33]

c) The Medial group – consists of the adductors of the leg (there are 5 but the only one with an effect of the function of the knee is Gracilis)

Muscle	Origin	Insertion	Action	Innervation
Gracilis	Inferior rami of pubis and the body of the pubis.	Medial Surface of tibia	Adduction of the thigh and flexion of the leg at the knee.	Obturator Nerve

Table No.4: Muscles in the medial compartment of the thigh working on the knee joint. [36]

From the muscles groups, one can observe that the anterior compartment muscles affecting the knee joint work on extension of the leg with the exception of the Sartorius. The Sartorius behaves like the muscles on the posterior compartment which activate to flex the leg at the knee joint. The posterior compartment muscles go further as to rotate the knee medially or laterally. The medial compartment consists of only one muscle affecting the knee joint, and its function is to also flex the knee.

1.17 Blood Supply of the knee

Arteries which supply the knee joint and surrounding structures branch from the Femoral and Popliteal arteries and the popliteal artery is the continuation of the superficial and femoral artery. These arteries pass through the popliteal fossa, and pass blood to the knee, to the ankle and foot.

- Popliteal artery: continues from the femoral artery at the adductor hiatus. Runs down the popliteal fossa divides into tibial arteries.
- Descending branch of the lateral circumflex femoral artery – supplies blood to the lateral leg (knee).
- Descending branch of the superficial femoral artery – supplies blood to the knee posteriorly.
- Genicular arteries branch from the popliteal artery - supplies blood at the posterior aspect of the knee. There are 5 of them: medial superior, lateral superior, medial, medial inferior, lateral inferior (arises from the femoral artery).
- Anterior tibial artery: found in anterior compartment of the leg and continues to ankle. Supplies the anterior structures of the leg.
- Posterior tibial artery: found in posterior compartment of the leg. Supplies to posterior and lateral compartments.

The veins taking the blood back to the heart from the knee and the surrounding structures begins from the posterior tibial vein and goes upward to the popliteal fossa, to the femoral vein in the thigh.

- Lateral superior genicular vein: located superior to lateral condyle of the femur and drains into the popliteal vein.
- Lateral inferior genicular vein: located inferior to lateral condyle of tibia and drains to the popliteal vein.

- Great saphenous vein: it is a superficial vein travelling from the foot, along medial side of knee, the way to hip.
- Small saphenous vein: it is a superficial vein that travelling along the lateral side of ankle to posterior leg into popliteal vein. [55] [31]

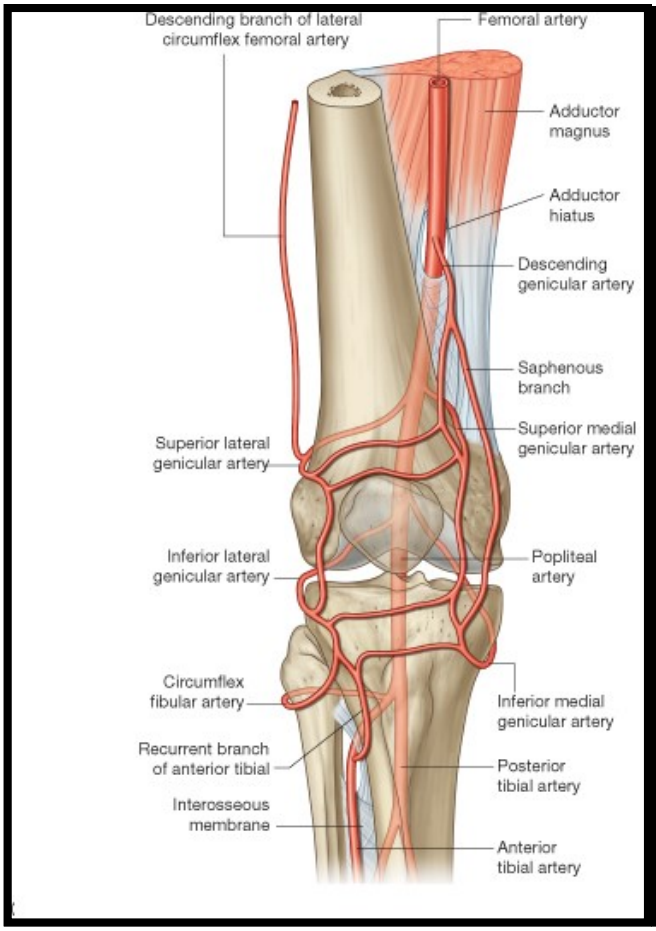


Image No.13: Arterial blood supply of the knee. [2]

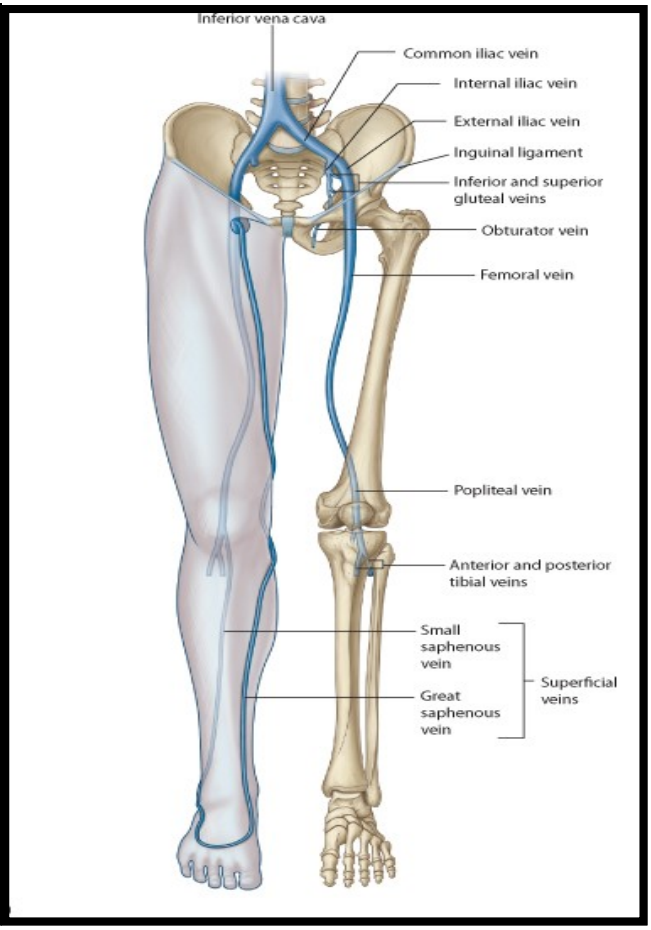


Image No.12: Venous blood supply of the knee joint. [2]

1.1.8 Lymphatic Nodes

There are lymphatic nodes found in the popliteal fossa, known as the popliteal lymph nodes). The lymph nodes receive lymph from the superficial and deep lymphatic vessels and joint capsule. The superficial lymphatic vessels from the lateral side of the foot and leg accompany small saphenous vein to popliteal nodes. The deep lymphatic vessels follow along sides of deep veins of leg to popliteal nodes. The lymph from these nodes flows in deep lymphatic vessels of thigh to the deep inguinal nodes. [56]

1.2 Biomechanics of the Knee Joint

Biomechanics is a subject that is a combination of ‘bio’ looking at the study of life and ‘mechanics’ focused on the action of forces. Therefore biomechanics looks into the mechanical aspects of living organisms. The forces studied are either internal (forces produced by muscles) or external forces (coming from outside affecting the body). This chapter will look at function of the structures of the knee joint from a biomechanics perspective.

1.2.1 Structure of the knee

The knee joint is s synovial joint made of three articulations that work together in its function of weight bearing. The two condylar articulations from the tibiofemoral articulations the most responsible for the weight bearing of the joint. Although the knee joint consists only of the tibiofemoral and patellofemoral articulations, it is also affected/influenced in motion by the tibiofibular articulation, as they are linked through surrounding soft tissues. [24]

i. Tibiofemoral Joint:

This joint is created by the articulations of the medial and lateral condyles of the femur and tibia, making it a hinge joint with slight room for lateral and rotational motions due to the restricting ligaments on either side. The condylar shape of the femur and tibia are different: the tibia’s condyles form a depression creating the intercondylar eminence. The eminence allows the tibia to laterally rotate about the femur during full extension, helping the knee to lock, this is known as the “Screw-Home Mechanism”. The shape of tibia plateaus vary from person to person as they are complex and asymmetric in nature. This variety in nature results in some individuals having more ‘stable and resistant to injury’ knee joints as compared to others. [24]

ii. Menisci:

Deepen the articulation of the tibial plateau. The meniscus works to resist compression or reduce the impact of stress in the knee joint. Its internal structure, the 2/3rds if the medial meniscus focuses on shock-absorption. It has been proven that without the meniscus, the stress applied to the tibiofemoral joint can be recorded 3 times higher when load bearing. An injured knee with a torn meniscus can function normally but the stress on the condyle the articulations can experience wear and tear resulting it degenerative conditions. [24]

iii. Ligaments:

These structures in the knee work collectively to provide stability in the knee joint. Their location in the joint determines the direction of forces they are countering. The medial and lateral collateral ligament resist forces acting in the frontal plane of the knee. The medial collateral ligament prevents valgus and rotational forces meanwhile the lateral collateral ligament prevents varus and rotational forces. The cruciate ligaments in the knee resist forces acting in the sagital plane of the knee: the ACL resists forces acting on the knee in the posterior to anterior directing and the PCL resists forces acting on the knee anterior to posterior. There are other structures contributing to the stability and function of the knee joint: oblique and popliteal ligaments, which cross at the posterior side of knee, the iliotibial tract, is a thick band of fascia latae and attaches to the lateral condyle and lateral tubercle of tibia. The Iliotibial tract works to laterally stabilise the knee joint. [24].

iv. Patella

The patella in this joint covers a number of biomechanical aspects. Most importantly the patella increases the angle of pull of quadriceps tendon on tibia, thus increasing the mechanical advantage of the quadriceps muscles, allowing them to produce 50% of knee extension. The patella also aims to centralise the diverging tension created by the quadriceps muscles. This structure also increases the area of contact between the patella tendon and femur, reducing contact stress of the Patellofemoral joint. Another importance of the patella is its protection of the knee

joint from forces acting on the anterior side of the knee. Lastly the patella stops quadriceps tendon from friction with adjacent bones. [24].

1.2.2 Movements at the knee

According to the anatomy of the knee, the knee joint is functioned by muscles from posterior, anterior and medial aspects. Some of the muscles work solely on the knee joint (one joint muscles) and others work on the knee joint and the hip joint (two joint muscle).

i. Flexion and Extension

Looking closely at mechanism of the primary movements in the knee joint (FLX*, EXT*): due to the structure of the articulations in the tibiofemoral joint, flexion is a motion that occurs in a series of steps, from the position of full extension. The medial condyles' articulation in this joint is longer than that of the lateral condyles, making motion on this side of the articulation almost absent, this is where the "locksmith" method is applied. The muscle popliteus acts as a locksmith in the tibiofemoral articulation: it causes the tibia to medially rotate, in turn allowing room in the medial condyle articulation, giving room for flexion.

During flexion the femur glides anteriorly, preventing rolling off of the tibia plateau and glides posteriorly during extension. The medial rotation of the tibia, influencing the anterior translation of the fibula also occurs during passive flexion of the knee. This movement of the tibia varies in degree due to difference in load and individuality in people. [24]

ii. *Rotation and Passive Abduction and Adduction*

Rotation of the tibia against the femur is possible only in knee flexion and without weight-bearing of the extremity. The optimal position to get the greatest rotation degree is when the knee is flexed to 90^{o}. The muscles that influence medial rotation are: Semitendinosus, Semimembranosus and popliteus, with the help of Gracilis and Sartorius. Meanwhile lateral rotation is solely achieved by the Biceps Femoris. [24]

iii. Patellofemoral Joint Motions

The patellofemoral joint's motion is dependent on the motion of the tibiofemoral joint (FLX/EXT): during flexion the patella the patella glides inferiorly and superiorly during extension with a measurement of approximately 7cm. The patella's position and movement in the sagital and transversal planes is highly influenced by the net force provided by the attached quadriceps; the Vastus Lateralis pulls the patella in a lateral direction and the Vastus Medialis counteract the vastus Lateralis pull, resulting the resting of the patella in the patella groove. Another influential factor on the position and motion of the patella is the Iliotibial band, excessive tightness of this structure causes pathological movement of the patellofemoral joint and/or positioning of the patella. [24]

1.2.3 Loads on the Knee

The knee joint is located between two of the 'longest bone levers' in the body (Femur and Tibia), making the potential for torque (a twisting force that causes rotation) high.

i. *Tibiofemoral Joint*

This joint has two forces acting on it constantly: shear and compression. The tension and weight bearing in the surrounding muscles contribute to these two forces. Compression force in the tibiofemoral joint is mostly present during full knee extension. During normal gait pattern, the compression force changes, it is highest during stance phase where it is three times the person's body weight. During stairclimbing it increases to four times the person's body weight. The tibia's medial plateau is bigger than the lateral allowing it to take up most of the compression load during stance phase and knee extension, meanwhile the lateral takes up smaller forces during swing phase of gait. Due to the medial plateau taking up most of the load, it has an articular cartilage three times bigger than the lateral which helps to prevent wearing of the joint.

Another structure in the knee joint that takes part in load distribution is the mensci. The menisci distributes load over a broader area reducing the stress acting on the joint. It also aids with force absorption up to 45% of total load. Menisci's

additional function is to reduce effects of stress on the knee joint preventing wear of the joint: individuals that undergo meniscectomies are likely to develop degenerative conditions.

It is well known that the knee joint is weight bearing therefore making it prone to stress: the joint is maximally stressed at flexion from 180^{o}-120^{o} of flexion and minimally stressed at 30^{o} flexion. Factors that contribute to larger loads acting on the knee are:

- Reduced flexibility in hamstrings
- Greater body weight
- Greater weekly mileage
- Greater muscular strength [24]

ii. *Patellofemoral Joint*

During normal gait pattern, the compression force acting on the patellofemoral joint is half one's body weight. However as flexion increases in the knee joint during weight bearing, the compression force in the patellofemoral joint increases: for example during stairclimbing, the compression force in the PF joint increases to about three times the persona body weight. There is this correlation between knee flexion and compression force in the PF joint during weight bearing because of:

1. An increase in knee flexion increases the compressive component of force acting the knee joint as a whole.
2. As flexion increases in the knee, there is an increase in quadriceps tension (quadriceps Femoris tendon attaches to patella) preventing the knee from buckling against gravity.

One of the gait modifications is the 'squat', this is a very popular motion or form in our exercise routines. It is very effective during knee rehabilitation for example after cruciate ligament injuries or patellofemoral surgeries as squatting can be very stressful on the knee complex. Squatting produces patellofemoral joint reaction (force generated within a joint in response to forces acting on the joint of 7.6 body weight. The PF joint reaction increases (with little difference) as the

squat deepens. To reduce the forces acting on the PF joint during knee flexion, it is ad

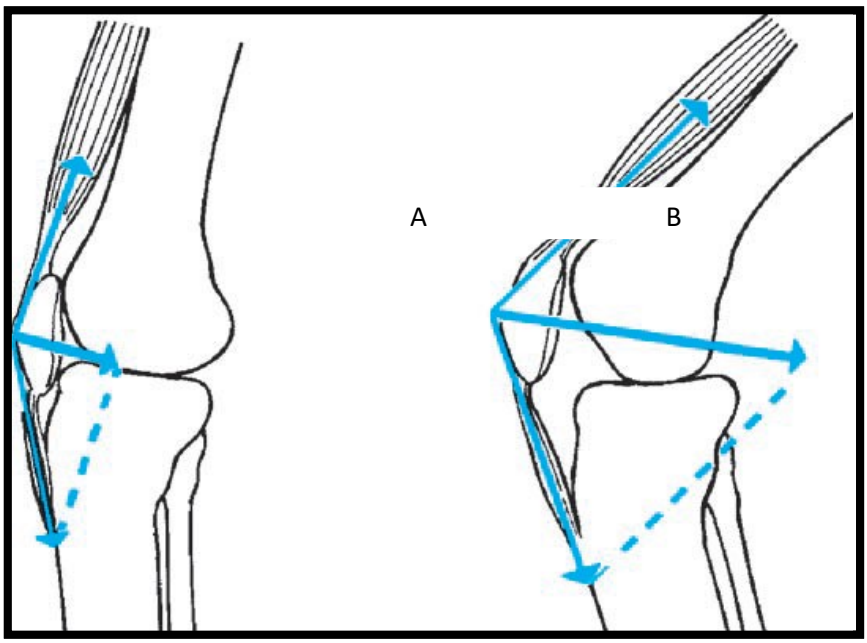


Image No.14: A. The knee in EXT and B. the knee in FLX. This image is an illustration of the relationship between the quadriceps tendon tension increase and the patellofemoral joint compression increase. [24]

1.2.4 Forces acting on the knee and role of ligaments

i. Anterior Cruciate Ligament

The ACL plays a very important role in controlled, stable and fluid movements in the knee, specifically in the direction of flexion and rotation of a 'normal' knee. Primarily the ACL counteracts the force acting to translate the tibia anteriorly against the femur. Secondarily the ACL counteracts forces acting to cause internal rotation, varus, valgus and hyperextension in the knee. It is important for an individual to have knee stability, and it most optimal to test anterior knee instability when the knee is in 30º of flexion. When there is flexion in the knee and a force (in anterior direction) is applied, it is more likely to cause anterior translation as compared with the knee extended; but as flexion increases translation decreases. The anterior cruciate ligament's ultimate stress level appears around 15% of tension: when the tension increases past 15% to 30%, there is gross failure of the ACL or translation of about 1cm. The medial meniscus also works in line with the ACL preventing anterior translation of the tibia. When there

is lack in proper function of ACL and a medial meniscectomy, there is a much higher risk of anterior translation of the tibia. [22]

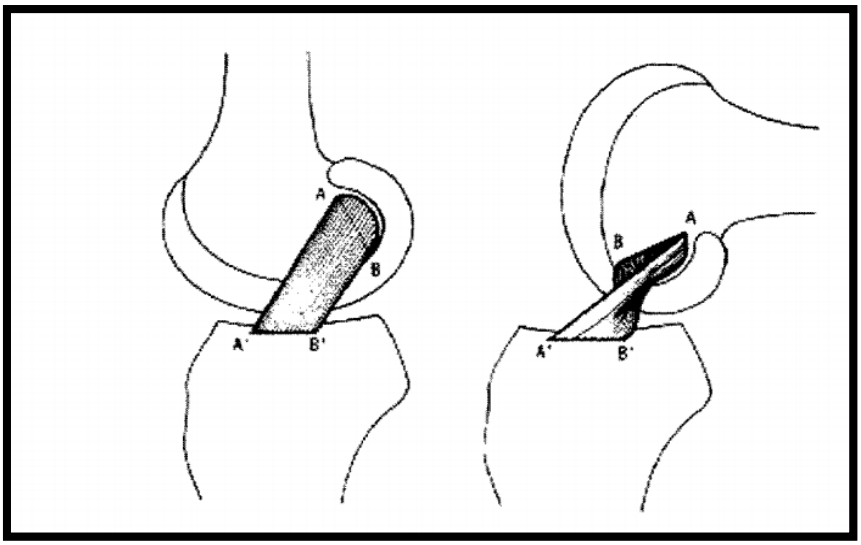


Image No.15: The changes in the ACL during FLX and EXT. During flexion anteromedial band lengthens (A-A), during extension posterolateral band lengthens (B-B). [22]

ii. Posterior Cruciate Ligament

The PCL is very important when it comes to alignment of structures making up the knee joint (femur and tibia), and it plays a helping role in stability. The posterior cruciate ligament's primary role is to counteract the force causing posterior translation of the tibia against the femur. Its secondary role is to counteract forces acting on the knee resulting in varus, valgus and external rotation of the knee. When the knee is flexed at 30-90º, the PCL provides 90-95% of restraining force to posterior translation: this makes it impossible to not injure the PCL during abnormal Posterior translation. The following results of an experiment conducted in the research of *"An in vitro biomechanical evaluation of anterior-posterior motion of the knee"* showing the important role of the posterior cruciate ligament in prevention of posterior translation of the knee: if 100N force is directed towards the knee in posterior direction, a healthy knee results in 6mm posterior translation, meanwhile a knee with a sectioned PCL has a translation of 15mm or more To test the posterior drawer of the knee during clinical examination, it is best to have the knee flexed at 75º. [22]

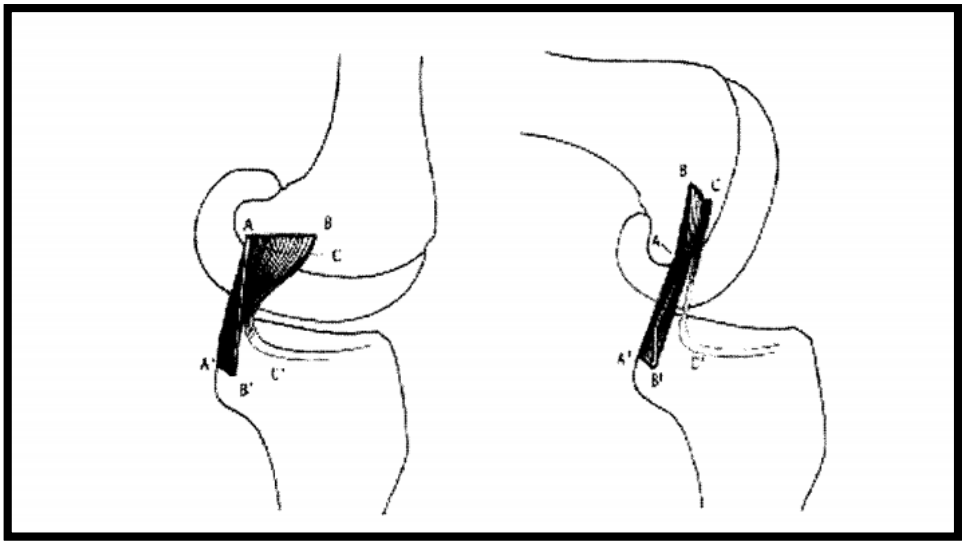


Image No.16: The changes in PCL during FLX and EXT: during flexion anterolateral band lengthens (B-B) and during extension posteromedial band lengths (A-A). [22]

iii. Medial Collateral Ligament

This structure is important for restraining valgus rotation and checks against external rotation, straight medial and lateral translation of tibia. Its function is in demand as flexion increases. The fibres of the MCL are divided into superficial and deep: the superficial aid in stability of the knee. According to the research conducted by the authors of "The prime static stabilizer of the medial side of the knee", the superficial layer of the MCL is the most crucial. This was proven by conducting an experiment that sectioned the superficial MCL and applied valgus load to the knee: the results showed that there was joint space opening throughout out the movement in the knee, additionally external rotation doubled in extension and tripled by 90^{o} flexion. Meanwhile sectioning of the deep MCL had little to no effect as the valgus force acted on the knee. The function of the medial collateral ligament increases as flexion in the knee increases, due to the slack of posterior capsular structures. [22]

iv. Lateral Collateral Ligament

The LCL works primarily to resist varus forces acting on the knee in all degrees of flexion. Secondarily this ligament also works to resist forces causing external rotation and posterior translation in the knee joint. LCL's ability to counteract varus forces at all angles of flexion is supported by the dynamic effect of the aponeurotic layers of the long and short heads of muscle Bicep Femoris, as they provide LCL with constant/continuous tension. This ligament is tightest in extension and slowly relaxes during flexion after 30^{o} due to: it being located behind axis of flexion-extension rotation and the radius of curvature of lateral condyle decreases during flexion. LCL remains taut between 0^{o}-30^{o} therefore it resists varus instability in this range. When the knee is in full extension, the LCL resists about 55% of the varus load targeting the knee; therefore isolated sectioning of LCL results in an increase of external rotation at all angles of flexion in the knee (with exception of 60^{o}). [22]

1.2.5 Forces acting on adjacent structures to the knee

i. Iliotibial Band

Although the IT band may not be directly part of the knee joint it sure has an effect on the function of the structure. The IT band prevents a varus opening and acts as an important stabilizer of the knee. When the knee is flexed, the band tightens and moves posteriorly, causing the band to release a posteriorly directed external rotation force on the lateral tibia. The band is tightest when knee flexion is occurring between 10^{o}- 30^{o} making it most vulnerable to injury in this position. On the other hand, during extension the tract moves anteriorly, protecting during varus stress and posterolateral injury of the knee. [22]

1.3 Kinesiology of the Knee Joint

Kinesiology is a holistic science studying movement: more specifically it deals with problems of voluntary and purposeful movements in human beings. Kinesiology is a broad discipline, it primarily covers information from human physiology, biomechanics and anatomy. It may also branch out into psychology, philosophy ecology and sociology of exercise and sports.

Kinesiology gives an understanding of important areas in the body with an influence or relation to movement. Anatomy teaches the parts and placements of structures in the human body, physiology then explains how these structures move and interact with each other. Biomechanics then uses concepts in engineering to develop a deeper understanding of human physiology and the physical limits of the structures in the system.

There are structural terms used in kinesiology which aid in classifying structures in the human body.

- *Supporting structures:* these are bones, joints, ligaments. Therefore focusing on the knee joint: bones are Femur, Tibia, and Patella. Joints are patellofemoral and tibiofemoral articulations. Ligaments (major) are anteriocruciate and posteriocruciate, medial collateral and lateral collateral ligaments.
- *Executive structures:* these are skeletal muscles. Focusing on the knee joint the muscles are: the Quadriceps Femoris, Hamstrings, Sartorius, Gracilis and Popliteus.
- *Infrastructure:* system providing energy supply. The knee joint's energy comes from its blood supply from the femoral, popliteal and tibial arteries.
- *Control structure:* the nervous system controlling voluntary movement. The knee joint's voluntary movement are controlled by the femoral, sciatic and obturator nerves.

1.3.1 The lower extremity

In this chapter we shall study the knee joint from a kinesiology point of view. This means there will not just be a focus on the knee joint, rather we shall look at how the knee joint integrates into the entire lower extremity.

The lower extremity is a structure focused on supporting the body weight whether in motion or stationary. For a person to appear with a physiological gait or posture, there must be individual physiological functioning of all joints in the LE. An impairment in the joint motion or muscular control can alter the stance stability and stride length at different magnitudes. In the case of a shortfall (e.g injury) in a particular area of the LE, adjacent structures work to compensate for the loss in function of the deficit structure. The degree of shortfall has a positive relationship to the degree of compensation: it then reflects in one's posture and/or gait with the same degree. For example in stance, you can see someone's weight shifted to one side, or a rotation or need for aids and in gait, the person may tend to walk slower, or in need of extra support or with shorter stride.

For a person to have a smooth/normal gait, their pelvis, hip, knee and ankle (and foot joints) must be working asynchronously. Timing and strength are determined by the muscles of the lower extremity. A person's stance stability is evaluated by three phases, which determine one's ability to walk.

- Normal stance: both feet on the ground, equal weight distribution. It evaluates the person's alignment.
- Single limb stance: it evaluates the person's weight bearing and body balance.
- Walking: it challenges trunk alignment as there is constant shifting of base (support).

Unlike its fellow hinge joint the elbow, the knee does not lock when it extends, rather it is stopped in extension at about 5^{o}-10^{o} by the tension created in soft tissues located on the posterior side of the knee. During stance when the leg is in full extension (locked in EXT), the quadriceps Femoris muscles (knee extensors) manage to relax, preventing them from overworking as the person maintains posture. [59]

1.3.2 Reverse Actions

The lower extremity at the knee joint can cause movement in two forms known as the 'reverse actions'. One form is open chain movement: this is when the lower leg is free during movement, causing the tibia to move on the femur. An example of this is swinging the leg when sitting at the edge of the bed. The other form is closed chain movement: this is when movements occur with the lower leg is contact with a surface. In this form of movement, the femur is moving on the tibia. An example of this is squatting. When training the knee, it is important to exercise in both forms: during exercising in open chain allows isolation of muscles meanwhile close chain exercises allow more function training as there is more integration of structures. [49]

1.3.3 Angulations at knee joint

i. Varus and Valgus

These two positions of the knee are measured or determined by the size of the angle found between the intersection of the medial line from the femur shaft and medial line from the tibia shaft both within the frontal plane. When it appears to be valgus, this means there is ABD of the tibia relative to the femur, and when it appears varus, this means there is ADD of tibia relative to the femur.

It is quite typical to have slight valgus in the knee about 5^{o}- 10^{o}. This is due to the angle of inclination of the femur, causing it to slant inwards as it meets the tibia. Many factors contribute to the development of a pathological degree of varus/valgus, the typical ones are:

- Pronation or supination [turning inward or outward] of the foot in weight bearing.
- State of knee collateral ligaments e.g. medial collateral ligament laxity causes valgus.
- Hip joint posture (rotation, ABD, ADD) e.g. medial rotation and adduction cause valgus in the knee joint.

Excess genu varus or valgus causes unwanted stress potentially leading to damage in the knee joint. For example increases genu valgus causes excessive

compression force at lateral tibiofemoral joint and excessive pulling force at medial tibiofemoral joint. Meanwhile excessive genu varum leads to extra compression force being applied to medial tibiofemoral joint and extra pull force at the lateral tibiofemoral joint. Increased valgus in the knee joint can contribute to the development of patellofemoral syndrome. [49] [65]

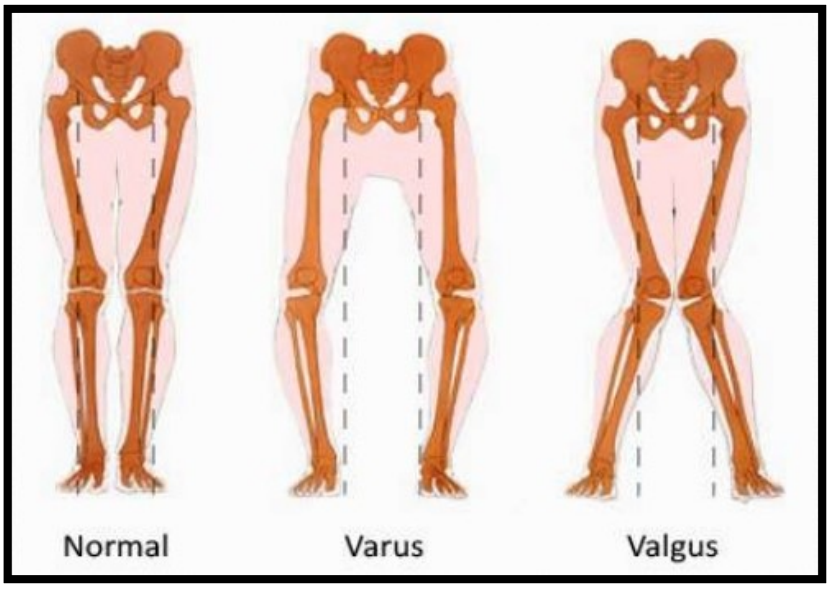


Image No.17: The lower extremities in normal, varus and valgus positions of the knee. [72]

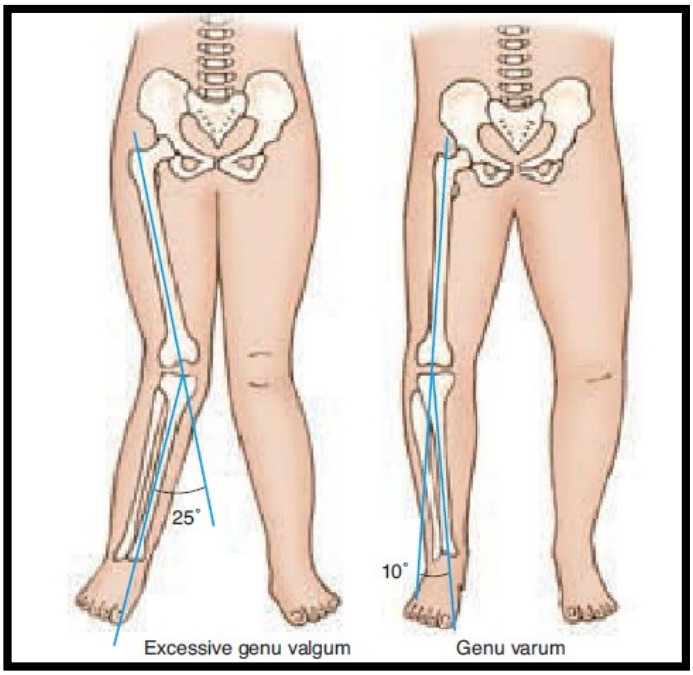


Image No.18: How to measure genu valgum and varum. [16]

ii. Q- angle

It describes the angle of pull of the quadriceps Femoris muscle group on the patella. It is measured between the intersection of a line arising from the tibial tuberosity to the centre of the patella and a line from the centre of the patella to the anterior superior iliac spine. The normal angle of pull is approximately between 10º-15º (can be to 18º), naturally because of the difference in pelvis shape, women tend to have greater q-angles than men. The greater the Q-angle, the greater the lateral pull of the quadriceps Femoris on the patella; due to this lateral pull, when the patella is gliding, it leans more on the lateral side of intercondylar groove. This imbalance can eventually damage the cartilage on the articular posterior surface of patella which is classified as *Patellofemoral Syndrome.* The lateral pull is further supported by the relative strength of the vastus lateralis in comparison to the medialis.

As there is a change in patella and femur position when the knee is either in varus or valgus, when the knee is positioned in valgus, the Q-angle increases. This brings unwanted stress to the patellofemoral joint Also changes in adjacent structure such as the iliotibial band and the lateral retinacula can affect the Q-angel. If they become tighter the Q-angle increases. [6] [47]

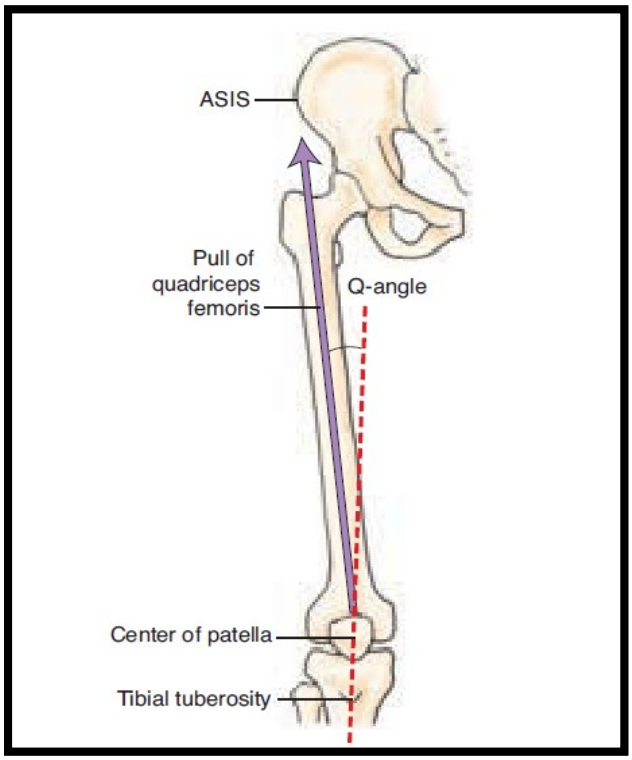


Image No.19: The measurement of Q-angle. [49]

iii. Genu Recurvatum

This angulation of the knee is also simply identified as hyperextension. It occurs when a person's knee extends past 10°: the angle is measured between the intersection of lines passing through the femoral shaft and tibia shaft. The knees tend to hyperextend as the posterior soft tissues structures of the knee fail to resist the force. Genu recurvatum is caused by two reasons:

- The shape of tibia platform: slopes slightly posterior.
- Centre of the person's weight falls anterior to knee joint while standing.

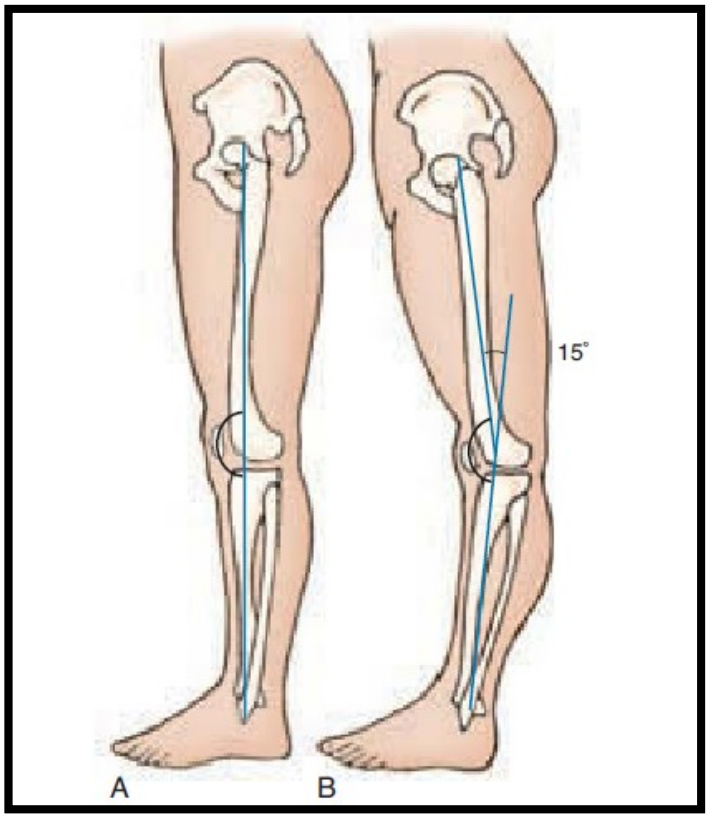


Image No.20: Genu recurvatum. A shows the knee at 0o (normal) and B shows the knee at 15o (genu recurvatum). [49]

1.3.4 The base of support and the lower extremity

The base of support is the foot when simply standing or walking. The foot positioning can affect the entire lower extremity structural positioning. In majority of people, during weight bearing, their foot can pronate (flat foot) at different degrees, this causes a medial rotation in the talus which in turn causes a medial rotation in the lower leg. Due the lower leg being medially rotated, there is a medial rotational force occurring in the knee joint. Meanwhile when supination occurs in the talus laterally rotates,

influencing lateral rotation in the leg, which brings about a lateral rotational force in the knee joint.

When in extension, the knee cannot rotate, therefore during weight bearing, these rotational forces caused by supination or pronation pass the knee and influence the hip joint. This alters its physiological functioning. Changes that occur in the hip joint due to these forces can be observed from the positioning of the patella, as the patella follows the femur. Pronation in the foot causes medial rotation of patella (and femur) and supination causing lateral rotation of patella (and femur). [16]

It is very useful that as a Therapist, when a patient presents with hip and/or knee joint problems to assess the foot during weight bearing, as fixing the function of the foot could realign the entire LE. There are various methods to treat pronation and supination of the foot, such as [59]:

- Orthotics
- Strengthening supinators of feet (when flat footed) and strengthening pronators (when maily they stand on outer foot)
- Strengthening of hip muscles: either lateral rotators or medial (according to pronated foot, and supinated foot respectively). This in turn corrects leg and talus positioning.

1.3.5 Muscle Chains

These are groups of muscles working together/influencing each other to create movement. There can be divided into three groups:

i. Synergist

These muscles work with other muscles to bring stability and motion to a joint. They are subdivided into primary and secondary movers, stabilizers and neutraliser muscles. Synergist muscles also work with force coupling (two equal and opposite muscle forces resulting in rotation at the centre of motion). Isolated joint movements are associated with synergist muscle action. In the lower extremity there are two movements produced by this type of muscle action:

- Extension synergy – causes IR, ADD, EXT of hip and knee and EXT plus inversion of ankle.

- Flexion synergy – causes ER, ABD, FLX of hip and knee and FLX plus eversion of ankle.

The degree at which these movements manifest and dominate vary from person to person. [52] [57]

ii. Muscle Slings

Unlike synergistic muscles, muscles in muscle slings are not working locally but globally. They active to transfer forces from the lower extremities, to the trunk, to the upper extremities and facilitate rotation. As they work across joints, they are also providing stability to these joints. Muscles in slings are interconnected, meaning their strength is not concluded on individual muscle(s) rather it is thought of globally; one muscle insertion connects to the next muscle origin. This relationship is supported by bony structures (keystone structures). In the lower extremity you can find two main slings:

- Extension sling – consists of the gluteus maximus, rectus femoris and gastrocnemius which cause: EXT of hip and knee and ankle PF.
- Flexion sling – consists of iliopsoas, hamstrings, tibialis anterior which cause: FLX of hip and knee and ankle DF.

During gait, these two slings alternate (facilitating and inhibiting alternatively) when both are activated, the LE is stabilized. During swing phase of gait, the flexion sling is facilitated, and during stance phase the extension sling is facilitated. [57]

Muscle sling	Keystone
Rhomboid, serratus anterior	Scapula
Rhomboid, triceps	Scapula
Trapezius, biceps	Scapula
Biceps, pectoralis minor	Scapula
Biceps, pectoralis major	Humerus
Latissimusdorsi, triceps	Humerus
Serratus anterior, external oblique	Ribs
Pectoralis major, internal oblique	Ribs
Internal oblique, external oblique	Linea alba
Internal oblique, gluteus medius	Pelvis
Internal oblique, sartorius	Pelvis
External oblique, adductors	Pelvis
Hamstrings, gluteus maximus	Pelvis
Gluteus maximus, contralateral latissimus dorsi	Pelvis, thoracolumbar fascia
Gluteus maximus, quadriceps	Femur
Hamstrings, hip flexors	Femur
Hamstrings, tibialis anterior	Tibia
Quadriceps, plantar flexors	Tibia

Table No.5: Muscle slings and their keystones. [57]

Due to muscle sling's ability to work globally, they are good for strength training of the entire body or two or more regions. It is challenging to train functionally as multiple joints and planes are involved hence you can spot a person's weakness better than during isolated movements. For example instability manifesting in the LE can be caused by weakness in the core, making standing on leg and moving other extremities difficult [3].

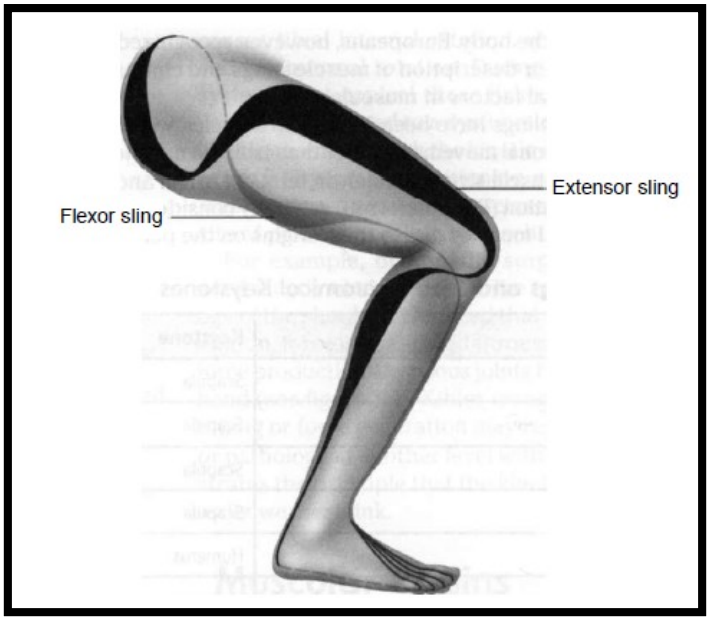


Figure 21: The muscle slings in the lower extremity. [57]

iii. Myofascial Chains

Like muscle slings they act globally, but differ as myofascial chains integrate joints through fascia, which encompasses muscles surrounding the joints. They are a very crucial link for activation of muscles acting together for movement. Another use of myofascial chains is to like extremities through the trunk for example: the thoracolumbar fascia links the LE to contralateral UE causing a relationship between LE extension and trunk rotation. Fascia has an ability to react to stress in the body changing its structure: fascia has the ability to tighten. When it tightens (loses its extensibility) due to its close relationship with muscle, it limits the movement in muscles causing a lesser ROM in joints. There are a number of myofascial chains, listed below are some illustrating how they work. [57]

- Superficial back line – it runs on the posterior side of the body from the bottom of the foot to knees from the knees to the eyebrows. It works to protect the posterior structures and importantly to prevent the body to naturally fall into flexion but causing extension. There is an exception of its extensive nature in the knees where it allows flexion. Its tendons near the knees help the cruciate ligaments to align the tibia and femur. [50]

- Superficial front line: it runs from the top of the foot to the pelvis from the pelvis to the sides of the head on the anterior side of the body. It works to protect internal structures found on the anterior side of the body, and importantly balances out the forces caused by the superficial back line by supporting flexion of the body. It maintains postural extension of the knee. [51]

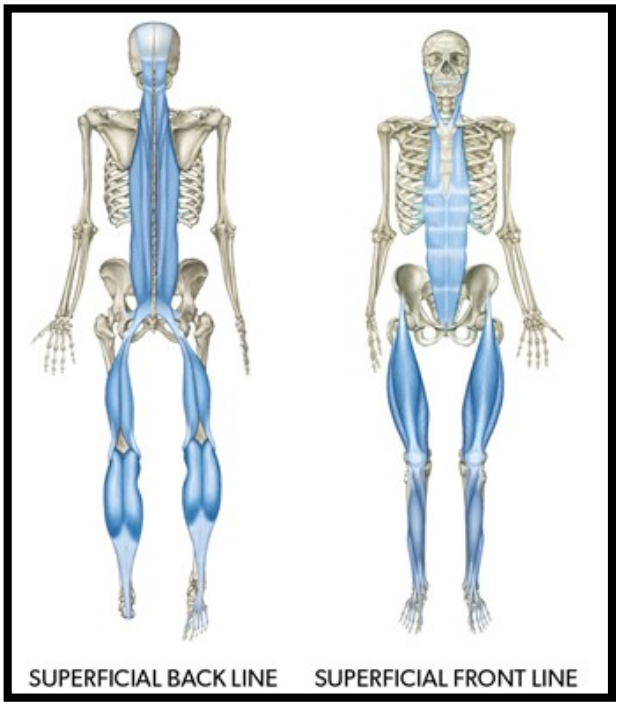


Figure 22: The paths of the superficial back and front line myofascial trains. [61]

1.4 The Diagnosis – Total knee replacement

This chapter will cover information of the diagnosis of the patient (total knee replacement). It will touch a little on the history, how it performed, what leads to it and the rehabilitation process.

Total knee replacement lies under the umbrella of 'Knee replacements' also known as 'Arthroplasties'. There are five main types of knee replacement surgeries with 'total knee replacement surgery' being the most popular:

- Total knee replacement – the entire surfaces of the knee joints are replaced.
- Partial knee replacement – it is better suited for knees partially damaged and patient has strong knee ligaments. Making it more suitable for younger people (55-64).
- Knee cap replacement – when only the posterior surface of the knee cap.

- Complex/revision – it for those with very severe knee problems (e.g. arthritis) or have had more than one knee replacement surgery.
- Cartilage restoration – suitable when the knee has an isolated region with wear or injury. This area can then be replaced by cartilage or graft cells [53] [49]

1.4.1 Causes of Knee Replacement Surgery

This treatment procedure is necessary to apply when the person's knee is worn out or damaged, causing a progressive increase in constant pain and reduced range of motion in the joint. Knee replacement surgery is performed on a patient as a 'last resort' method of treatment due to failure of the primary treatment methods (physiotherapy and steroid injections). It is better to attempt treatment firstly with the primary treatment methods because the Knee replacement procedure is quite complicated.

The patient is offered Knee replacement surgery when:

- The knee joint has severe pain, swelling and stiffness. All contributing to loss of joint mobility.
- The knee pain interferes with the quality of the patient's ADL and sleeping.
- The pain is so terrible it puts you in a state of depression as it is limiting.
- Work is affected due to the pain and stiffness in knee joint.

Therefore increasing pain and constant stiffness resulting in decrease daily function lead to Knee replacement surgery. This pain and stiffness felt in the knee are manifestations of the primary causes of knee replacement, these are: [39]

- Osteoarthritis – most common form of arthritis (inflammation of the joints). OA is also known as 'Wear and tear' arthritis as it is linked to breaking down of cartilage in joints.
- Rheumatoid arthritis – form of arthritis. It occurs when the immune system is attacking lining of the joints (synovium). It can affect other structures such as eyes and the circulatory system.
- Haemophilia – rare blood disorder that causes a lack in sufficient clotting factors causing blood clotting failure. Haemophilia is considered among genetic disorders.

- Gout – caused by an accumulation of urate crystals in the joints leading to arthritis.
- Unusual bone grown disorders – bone is a living tissue with complex functions making it prone to disorders or diseases. Some of these pathologies can cause excessive bone grown, an example being 'acromegaly'. [28]
- Necrosis of bone in knee joint after problems with the blood supply
- Knee injuries
- Knee deformity with pain and loss of cartilage.

1.4.2 Osteoarthritis/Arthrosis

Arthrosis is the leading or most popular cause of Total knee replacement (TKR). It is the result of protective cartilage on the ends of bones wearing down over time allowing bones to rub on each other. This disease is said to be more common in women as compared to men. All joints in the body are at risk of OA, but it mainly affects knees, hips, spine and joints in hands. Osteoarthritis affects the entire joint: it changes the structure of the bones, decreases integrity of the of the connective tissue surrounding and in the joint and causes inflammation of the joint lining. [37] [13]

Osteoarthritis can be divided into primary and secondary, this classification is not based on differences in signs and symptoms rather by the difference in aetiology. [68][26]

- Primary OA – known as 'wear and tear', and it is the most commonly diagnosed. It mainly starts to show between the ages 55-60, therefore linking it with aging. Due to its relationship with age, everyone is at risk of developing it as they get older.
- Secondary OA – this type of arthrosis has a recognisable cause (e.g injury, genetics). It usually begins in younger ages, around 45-50.

i. Risk factors/Causes

- Age – the older you get the chances of getting osteoarthritis increases.
- Gender – women are more likely to develop OA than men
- Obesity – carrying a lot of body weight puts stress on your weight bearing joints. This stress leads to arthrosis, the greater your weight the greater the chance of getting arthrosis. Besides the weight, the fat tissue creates proteins that cause harmful inflammation in and around the joints.

- Joint injuries – sport and accident injuries increase the risk of osteoarthritis no matter the age or healing outcome of the injury.
- Repeated stress on the joint – daily activities, jobs or sports can cause repetitive stress on the joint leading it to potentially develop osteoarthritis.
- Genetics – development of osteoarthritis can be seen through generations.
- Bone deformities – people can be born with malformed joints or faulty cartilage.
- Certain metabolic diseases – people with diabetes are at a higher risk of obtaining osteoarthritis or those with high levels of iron
- Race/ethnicity – we have differences in anatomical structures
- Diet – according to [54] vitamin D shows importance in preventing OA.

ii. Symptoms of Osteoarthritis

The symptoms of arthrosis can present in episodes, which are in correspondence too one's activity levels and for some the weather too. When it is severe, the symptoms can be continuous. The symptoms of OA are as follows [54]:

- Joint tenderness
- Increased pain and stiffness when joints have not been moved for a while
- Joints appearing slightly larger than usual (swelling)
- Grating or crackling sound or sensation in the joints
- Limited ROM in the joints
- Weakness and muscle atrophy
- Bone spurs

1.4.3 Osteoarthritis of the knee

Best known as Gonarthrosis is the degenerative damage of the cartilage surrounding the bone composing the knee joint. There is an imbalance between synthesis of cartilage and the cause of its degeneration. Gonarthrosis is the most common form of arthritis. It is caused by the same risk factors of osteoarthritis but the main being: [26][68].

- Old age – the older generation are at higher risk. In the case young person obtains it, it is due to an occupation with heavy demand on the weight bearing joints of the body such as profession sports.
- Excess body weight
- Deformity of the foot leading to an inappropriate distribution of load in the joints.
- Acute and chronic inflammatory processes of knee joint.

i. Epidemiology of total knee replacement

This section will look at "how the use of total knee replacement surgery has changed overtime in the world". According to a study conducted in 2011 on "International survey of primary and revision total knee replacement" with results based on research from 18 countries (in North America, Europe and South Pacific) with population of 755million and 1324000 annual primary and revision total knee replacement procedures. According to the results collected from national inpatient databases and arthroplasty registers of each country, there has been an increase in the usage of TKRS surgery over the past decade. [42]

Country	Years of available TKA data	Annualized growth in TKA procedures	Annualized growth in procedure rate/10^5
Australia*	2003-2008	6.7%	5.0%
Canada	2002-2008	10.3%	9.1%
Finland	1997-2009	7.2%	6.9%
France	2002-2007	5.3%	3.6%
Germany	2005-2008	6.9%	7.1%
Italy	1999-2008	12.8%	12.2%
Netherlands	1997-2007	9.4%	8.8%
Portugal	1997-2008	17.0%	16.6%
Spain	1997-2008	11.5%	10.1%
Switzerland	1998-2008	14.7%	14.0%
United States	1997-2008	7.9%	6.8%

Table No.6: The compound annual growth rates of total knee arthroplasty from the research on "International survey of primary and revision total knee replacement". [42]

Total knee replacement procedure is said to be influenced by factors such as age, gender, ethnicity and many more. According to the study done in 2011 on "Epidemilogy of Knee and Hip Arthroplasty: A systemic review" – TKR has increased over the last 2-3 decades: it is seen to be in correlation with the aging of the population due to increasing longevity. Therefore supporting the fact that age plays a role on the need of TKR especially. A great difference in the need of TKR has also been noted based on gender, ethnicity and region: this could be caused by difference in socioeconomic status and health care delivery systems of a country. Individually, patient preferences and prevalence of osteoarthritis can influence the usage of TKR. [66]

ii. *Symptoms*

Like the obvious symptoms or OA the patient feels pain and loss of range of motion. When the patient has gonarthrosis, the pain manifests when:

- They do physical exercise or lifting heavy loads and importantly going up and down the stairs.
- During movement a secondary inflammatory process causes inflammation of the knee.

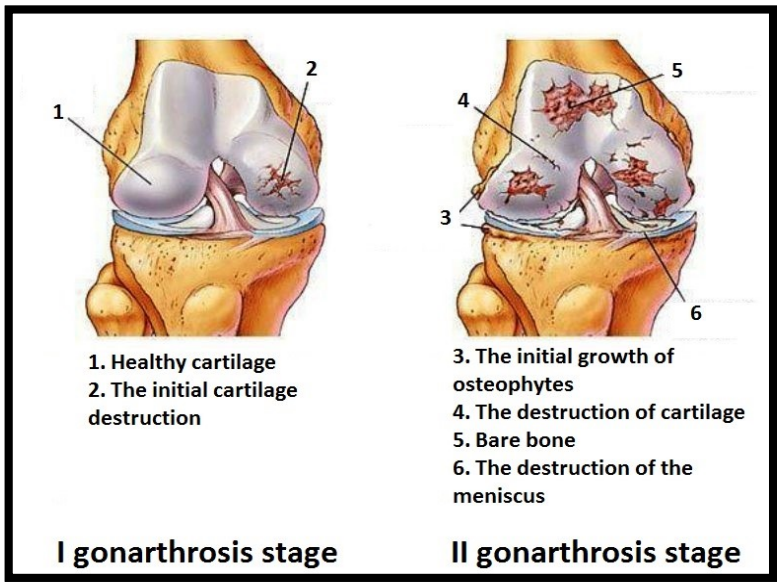


Image No.23: The development of Gonarthrosis. [26]

The symptoms of Gonarthrosis come up in stages. Stage one: external symptoms are not visible, patient feels pain during loadings (stair climing, or sitting to standing positon), and too much loading can lead to inflammation in centre of knee. Stage two: local wearing of cartilage, osteophytes form. During normal load (walking)

patient experiences pain and inflammation, there is decrease in ROM and atrophy of muscles begin. Stage three: pain and inflammation are at a constant (active and rest), blood circulation of knee is impaired. Contractures in joint can be formed due to lack of movement. [26]

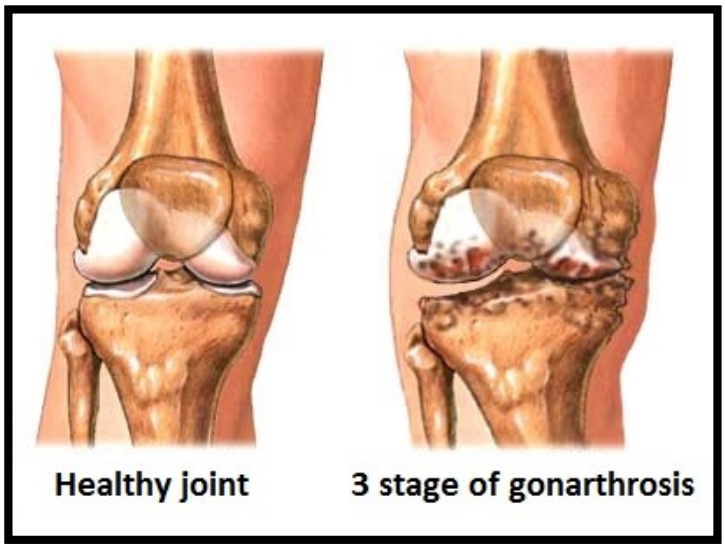


Image No.24: Stage 3 of gonarthrosis. [26]

iii. *Diagnosis*

Diagnosis of gonarthrosis can be performed by clinical and radiological examination methods. Magnetic resonance, arthroscopy and bone scintigraphy are also useful methods to use during diagnosis. The method used to diagnose is determined by the pain the patient describes and the expertise of the clinicians reading the radiographic images [41].

The clinical methods include having a full clinical picture through physical examination of the knee and history on the condition taken. It is important for the orthopaedic specialist to analyse the range of motion in the joint. The radiological images allow the specialist to confirm the clinical picture and analyse exactly how much of the joint is affected.

iv. Treatment

Gonarthrosis and all other forms of arthrosis cannot be cured due to the damage of cartilage being irreversible. Therefore treatment focuses on relieving

pain and slowing down progression of the arthrosis. There are two categories of treatment:

- Conservative treatment
    - Physiotherapy: for example corrective exercises balancing distribution of load on the joints (very useful when patient has deformities in legs and feet).
    - Orthopaedic supports such as elastic knee supports
    - Weight loss goal
    - Change in lifestyle: stopping activities that cause too much stress to the knees or if patient did nothing active prior, guided physical activity would be recommended.
    - Medication: patient can be given anti-inflammatory drugs (best in acute phases of the disease) and analgesic drugs
    - Arthroscopy of the knee: it is a minimally invasive surgical treatment whereby it eliminates the affected areas, formation of osteophytes and strengthening the ligamentous apparatus.
- Surgical treatment: it is only used when the conservative treatments are not changing the condition of the patient.
    - There is an option to build up secondary cartilage tissue during surgery. It manages to reduce or eliminate the pain, but the loading capacity of the new cartilage is not as good as the old.
    - When the gonarthrosis is severe, total/partial knee replacement are proceeded. [71].

1.4.4 Total Knee Replacement Surgery

This surgery has been one of the greatest developments of the 20th century in orthopaedic surgical treatments. It was first performed in 1968 after Frank Guston designed an unhinged knee as a result of inspiration by John Charnley who cemented metal on polyethylene in 1960 for hip replacement. The unhinged knee joint replaced both condylar sides (medial and lateral) with separate components, allowing the preservation of cruciate and collateral ligaments, which in turn improved the biomechanics of the joint. Maintenance of stability of femoral and tibial components and

the artificial design of the joint allowed the centre of rotation in the knee to change during knee flexion. The complete replacement of femoral and tibial articulating surfaces with metal-on-polyethylene condylar design is an implant that based its stability on component geometry and soft tissue balance. It also relied on the large articulating surface area to distribute load minimising polyethylene wear. Over the years, improvements have been done to the surgery which allowed: [48]

- Greater accuracy in sizing
- The option of patellofemoral replacement too
- Better instrumentation and advancements in components responsible for increase of ROM and lower wearing rate of the artificial design.

i. Types of Total Knee Replacement Implants (TKRI)

There is a variety when it comes to TKRI, they vary according to design, materials and fixation. They are tailored to each patient's requirements. The implant selection could be based on whether it should be fixed or mobile, PCL-retaining or PCL-substituting design, fixed with or without cement. The type picked is done by the surgeon based upon:

- The patient's physical state, age and lifestyle
- The surgeon experience and trust with a certain implant or brand of implant.

Although the designs of the implants vary, they are derived from three components 'basic components': femoral component is composed of metal and curves around end of femur, there is a groove in it allowing movement of patella. The tibial component consists of a flat metal platform with a polyethylene spacer, it varies in structure as it depends on the type of surgery performed. The patellar component mimics the knee cap, it is only used in some replacements. [4]

1. *Fixed bearing implants*: it the most common used implant, its name derives from the fact that the polyethylene cushion in the tibial component is firmly fixed to the metal platform base. Due to this fixation, the femoral component then moves on the tibial component; the fixed bearing implant has a good range of motion and is not prone to wearing. People usually face challenges

after this type of TKRI are rare, and those rare incidences occur due to excessive activity and extreme weight gain can lead to wearing of joint. When the joint is wearing out the implant loosens resulting in pain and joint failure.

2. *Mobile bearing implants*: this type is recommended to younger, more active or obese patients. It is designed for longer periods of performance and has less risks pf wearing. What makes it differ from fixed bearing implants is the fact that the polyethylene implant in the tibial component can slightly rotate in the medial tibia tray. The mobile bearing implants require more ligament support because of the extra movement gained in the joint due to the rotation. The knee is at risk of dislocation when the soft tissues are too weak to support the knee structures.
3. *Medial pivot implants*: this type of implant feels and behaves more like the actual knee. Unlike the fixed and mobile bearing implants, the medial pivot implants allow the rotation, flexion and stability of the natural knee. This is done by the implant letting the medial side of the knee be the pivoting centre as the lateral side rolls back during flexion. This mechanism prevents the knee from sliding forward during flexion with load, which can be observed in fixed and mobile bearing implants.
4. *Posterior Cruciate Ligament-Retaining or substituting implants*: this implant is based on whether the original PCL is kept (retaining) or removed (substituting). This conclusion is based on the condition of the original PCL, the type of knee implant and the surgical approach of the surgeon. In the PCL retaining implant, the femoral and tibial prostheses have room to accommodate the original PCL. Meanwhile the PCL substituting implant have higher surface on the tibial component cushion working in the place of PCL which gives your knee the same stability provided by the PCL.

Another factor that differs in the implants used it the fixation of the knee replacement implant. There are three forms of fixation: cemented, cementless and hybrid

- Cemented – the prostheses have a special kind of bone cement that aids in holding the artificial components of the joint in place. A larger number of implants are cemented and are usually successful, although they have had a small history of loosening in younger/more active patients.

- Cementless – these prostheses rely on bone growth into the implant to hold the artificial components together. Awaiting the bone grows, the implant is held in place by screws or pegs. The recovery time for this type of replacement is longer than that of cemented. It is not adviced for those with weak bones (due to conditions such as osteoporosis) to get this type of replacement.
- Hybrid – this prostheses replies on both cemented and cementless method. It is mainly popular in the hip joint.

The surgeon has the final say on the kind of knee implant and implant fixation to use but they are required to make the patient aware for the reasons of their choice as it determines the process of recovery of the patient. [4]

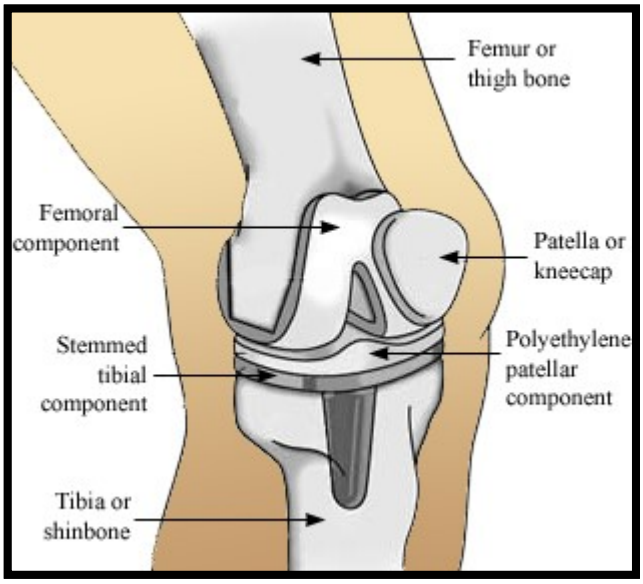


Image No.25: The implant is positioned in the knee joint. [41]

ii. Risks and complications of Total Knee Replacement Surgery

Although it is rare to have a complication as a result of TKR, it can still occur. These complications are likely to occur if the patient is a smoker, obese or very old. Other health conditions to consider prior to TKR are: uncontrolled diabetes, severe vascular disease, poor dentition, lab work indicating irregularities, inadequate nutrition. It is rare that these complications are life threatening. The two major complications/risks are: [5]

- Complications involving anaesthesia – there is a low risk of strokes, heart attacks, pneumonia and blood clots occurring. The most likely to occur is

deep vein thrombosis (DVT). It is managed by anti-clotting medication and wrapping around the affected leg providing intermittent pneumatic compression. If left untreated or caught late DVT can lead to a life threatening condition known as pulmonary embolism.

- Risks and complications of infection – patient is usually given antibiotics at the time of surgery, reducing the risk of infection. 2-3% of TKR patients can still get infected and are given more antibiotics, in other cases infection can be so bad the patient needs to remove the implant. If the infection spreads throughout the body, it is very life threatening. As the risk becomes smaller as the wound heals, one should still be careful and infection could still occur.

Other less common but potential complications are as follows:

- A part of the prosthesis can dislocate or become loose if misaligned or not seal adequately to the bone.
- There could be stiffness in the prosthetic knee. Scar tissue developed can hinder flexibility. This situation is more common in those inflexible prior to surgery.
- Allergic reaction to implant or cement. This complication results in removal of knee implant and bone cement.
- Damage of soft tissue soft tissue behind patella between patella and femur can occur.
- Legs can result in slightly different lengths post-surgery, leading to usage of shoe orthotics.
- Rarely there is damage to surrounding arteries, veins, and/or nerves.
- Rarely postoperative rapture of quadriceps tendon. It can barely occur but can be very devastating. [67]

According to research, patellofemoral complications in the knee joint prior to knee replacement surgery are more likely to develop due to osteoarthritis and obesity. Another factor to consider this complication is the type of implant and fixation method used: metal-backed patellar implants and with patellar components implanted without cement caused complications in the joint as

compared to TKR done with all polyethylene and patella components implanted with cement. [25]

iii. How to prepare for TKR surgery

Commonly, the patient has to wait 6-12 weeks to have TKR surgery. In that time, the patient is advised to partake in some changes that can lead or influence a better outcome of surgery and better recovery period. Prehabilitation of physical therapy is highly recommended as it focuses on strengthening of muscles surrounding the knee joint, improving functional tasks. This is very important as the preoperative performance of functional tasks of the joints can predict the postoperative performance of these tasks. It is possible to face weakness in the operated leg up to year after TKR, therefore eliminating this problem prior to the surgery gives potential to speed up the rehabilitation process after TKR. Besides prehabilitation, the patient is given suggestions on medical preparations. [69] [5]:

- Cut or decrease medications – two weeks before surgery it is advised for patient to stop consuming Asprin and other medications that cause difficulty in blood clotting. Steroids and other medications that inhibit the immune system. Opioid pain medication to help reduce tolerance to pain medication.
- Cut or decrease use of tobacco – as nicotine impedes healing and increases the risk of infection and deep vein thrombosis.
- Cut or decrease consumption of alcohol – patients consuming more that 1-2 alcoholic beverages per-day should make doctors aware as alcohol affects the effect of anaesthesia.
- Report illness – any random alterations in the patient's health should be reported (e.g. colds, flu, fever, herpes breakout).
- Specialist advice – those with medical conditions such as diabetes or cardiac diseases must consult specialists to confirm if they can have the surgery.

iv. Operation procedure

Total knee replacement is a surgery that takes about two hours from the time the patient is given anesthesia to the time they are sent to the recovery room. After the patient is ready on the operating table, the first step a surgeon take is to landmark regions on the Lower extremity used as guides during the incision. It is import to mark the following using palpation method as they landmarks are on subcutaneous level: anterior crest of tibia, patella, lateral and medial malleoli and fibula head. It is crucial to mark the femoral head, as it is not palpable, the surgeon marks it radiographically. [43] [23]

The surgery is performed in steps:

1. Surgical exposure – this is done in three steps. Firstly skin incision, followed by capsular incision and lastly capsular sleeve development.
2. Exposure of articular surfaces – the patella is carefully moved out of the way in order to expose the femur and tibia articulations. In this stage osteophytes on the femur and tibia are removed, followed by the removal of ACL to allow the anterior draw of the tibia as the knee rests in 100^{o} FLX. The draw of the tibia fully exposes the articular surfaces of femur and tibia.
3. Preparing the femur – resurfacing of the femur (cutting away the damaged bone and cartilage). When this is done, the femur component of the implant is inserted and sealed.
4. Preparing the tibia – resurfacing the tibia (cutting away the damaged bone and cartilage). When this is done, the tibial component of the implant is inserted and sealed.
5. Readjustment of the patella if necessary for a perfect fit into the new knee.
6. Finalising the procedure – surgeon mobilises the knee to ensure all is working correctly, properly aligned, sized and positioned. After the surgeon will go ahead and add two intra-articular vacuum drains, close the incision with staples or stitches, dress wound and cover entire leg with elastic compression bandage.

It is crucial to analyse the soft tissue around the knee, after the patella is reinserted as the patella can partially disturb the surrounding soft tissue. If the soft tissue is disturbed it forms a portion of a contracture resulting in either fixed varus or valgus and flexion deformities in the knee joint. [43]

1.4.5 Postoperative Training and Exercise of Total Knee Arthroplasty

Soon after the procedure, patient is taken to recovery room for a few hours and moved to hospital room where they stay for a couple of days (dependent on the hospital and patient's medical aid and condition). Patient is on analgesics to ease the pain. The patient is instructed to mobilise foot and ankle increasing blood flow to leg muscles, which in turn prevents swelling and blood clots. Prevention of clotting will be further assisted by blood thinners and swelling will be managed by support hose or compression boots [55]. Before leaving the hospital, patient must reach the following milestones during their treatment: standing, getting around with the help of a walking device, sufficient FLX and EXT of the knee and use of the bathroom without help [56].

A day after surgery a physical therapist will be introduced as the beginning of the training and exercise plan. The physiotherapy process has two stages, in and out patient. Inpatients are those admitted in a specialised section of the hospital meanwhile outpatients are those rehabilitating from a clinic or home both types of patients have guidelines from the physiotherapist.

Inpatients – are the ones in the acute phase after total knee replacement. As a physiotherapist the ultimate goal it is to improve the independence of the patient and bring functional capabilities to their optimum. This is achieved by a collective of methods which aid in bringing back mobility in the knee joint. These methods include:

- Manual and physical therapeutic methods helping to reduce the swelling in the knee and nearby joints and also help reduce pain.
- Passive, active-assistive, and easy active movements that help with strengthening of muscles around the knee joint and keep mobility and prevent shortening of muscles.

Outpatients – are those in the subacute to chronic stage of rehabilitation. The patient only becomes outpatient when he is independent as an inpatient. They can do basic

functional abilities on their own. Outpatients are training more functionally, and are usually given 'homework' (therapy to do at home by the therapist). What differs between outpatient and inpatient therapy is the intensity. For an outpatient the therapist starts focusing on active exercises involving balance training, strength training with resistance and functional training such as cycling. [19]

The physiotherapist purpose in the recovery of the patient is very important as it speeds up the recovery of the patient and prevents controllable complications from occurring as the therapist guides the patient. For the therapist's treatment to work at its best, they must follow some therapeutic guideline. The guidelines are just a backbone on what to expect and how to work around it, therefore do not necessarily apply to every patient.

i. *Therapeutic Guideline after TKR [14][46]*

Early postoperative review (0-2 weeks)

Aims – swelling control.. Increasing range of motion (at least EXT of 0 and FKX of 100^{o}) with focus being achieving full extension is another aim. Lastly another aim is self-mobilisation of patient.

Exercises – should be done twice a day. They should consist of: passive motions using CPM machine or therapist. Circulation drill, stretches of calf and hamstrings, isometric quad exercises (most important), straight leg raising, calf raises and flexion drills. Practice gait and stair walking using assistive devices and recommend load by surgeon on affected limb.

Physiotherapeutic modalities/methods – gentle massage or lymphatic drainage massage. Cryotherapy. Electrotherapy. Soft tissue techniques of scar and skin.

Mid stage postoperative review (2-6weeks)

Aims – personal scar management. Continue with methods used for swelling reduction. Another aim is to manage full extension (0^{o}), FLX ROM should be 120^{o} by the end of the sixth week. Patient should have obtained a close to normal gain. Lastly patient should avoid setbacks.

Exercises – if the patient has been discharged (outpatient), some of the exercises can be advised to be continued at home. Patient must attend sessions at least once a week. Exercises are now more focused on strength and light proprioceptive training. Also patient continues to perfect gait, aiming to eliminate the antalgic gait pattern. Deep stabilization training.

Physiotherapeutic modalities/methods - gentle massage or lymphatic drainage massage. Cryotherapy. Electrotherapy. Soft tissue techniques of scar and skin. Manual mobilization of patella. Proprioceptive neuromuscular facilitation (PNF) towards the 6th week. Kinesiotherapy around the knee and adjacent areas.

This is a very critical time in recovery, the knee implant hasn't fully settled, therefore overdoing the strength could lead to pain and swelling, causes a setback in the healing process.

Mid-Late stage post-operative review (6-12 weeks plus)

Aims – strengthening of joint. Returning to normal function (e.g. moving on stairs normally some even driving). Requirement to continue working on range of motion, EXT should be 0^{o} and FXL 130^{o} or more. Patient should continue working on scar tissue. Therapist should introduce walking on uneven surfaces and can stop using assistive devices on flat surfaces. Patient should be able to walk with full load on operated leg [64].

Exercises – focusing on strength and functional retaining with exercises such as bridging, squats, step ups, sitting and standing. Gait re-education and balance training should be continued. Cardiovascular exercises should be implemented (e.g bike and hydrotherapy, which could be started earlier in the treatment if the wound is dry and healed). Toward the 12th week, therapist could start demanding open kinetic chain exercises.

Physiotherapeutic modalities/methods - gentle massage or lymphatic drainage massage. Cryotherapy. Electrotherapy. Soft tissue techniques of scar and skin. Manual mobilization of patella. Proprioceptive neuromuscular facilitation (PNF) towards the 6th week. Kinesiotherapy around the knee and adjacent areas.

ii. *Follow up*

Doctor should be contacted immediately if: there is worsening pain and inflammation and redness around the wound or elsewhere. When fever begins or one starts to feel sick, and there is chest pain or shortness of breath. Most complications occur in the early 6 weeks of TKR surgery. It is recommended for patient to check up with their surgeon for the next year. [19]

2. Practical Chapter

2.1 Methodology

The conduction of the practical part of the thesis was done in Ústřední vojenská nemocnice (UVN) from 13th January 2020 to 7th February 2020. It was a total of four weeks and each day working for 4 hours.

My patient was assigned to me in the second week of my practice and I worked with him from the 20th of January to the 31st of January 2020 a total of 10 days consecutively. The patient was made aware of the Ethical conduct and agreed to it by signing the informed consent from the Ethics Committee, therefore all procedures to follow were done with an absolute and clear consent from the patient.

The patient I chose was an orthopaedic patient who had just undergone a total knee replacement. Each session lasted approximately 30 to 45 minutes and they consisted mainly of physical exercises and manual methods of therapy such as stretching, Post isometric relaxation and soft tissue work. The first therapy consisted of the initial examination of the patient: their history of the condition, their medical history, family history and their active daily living. After the history, the complete physical examination of the patient is done. In the last session with the patient, the final examination is done in line with the initial examination, which concludes on the effectiveness of the therapy. Besides our sessions, the patient was also undergoing cryotherapy and hydrotherapy, bicycle training and used the Continuous Passive Motion machine daily.

2.2 Present Status

Diagnosis: After Total Left Knee Replacement.

Name of patient: L.R

Gender: Male

Date of Birth: 1957

Height: 1.78

Weight: 97kg

BMI: 30.6

Subjective:

Besides the pain from the surgery, patient stated he is doing pretty well. He feels pain mainly in the lower quadriceps region: in the anterior and the medial areas. The pain is not always constant but feels uncomfortable. Flexing the leg is painful past a certain point. Patient fails to extend the leg actively. He is quite self-sufficient as he manages to move about well with crutches. Movements in bed are uncomfortable and worst position is side-lying on the operated leg.

Objective:

Patient was very cognitive and aware of his environment. Overal looked to be in good condition after two days post-operation. Patient presented with a normal body temperature, he had a good breathing rate. His skin was normal, no perspiration or discoloration of some sort. Patient has an endomorphic body type. He wears prescription eye glasses and is currently using crutches.

2.3 Anamnesis

i. *History*

Patient had a gradually increasing pain in left knee for 3to 4 years and it was restricting his ability to walk before he went to get checked. He had never faced any other joint pain prior to this. He got diagnosed with Bilateral Primary Gonarthrosis using X-ray and MRI. He had the surgery planned on the 16.01.2020 for total left knee arthroplasty. He had never done anything to ease the pain he currently felt.

ii. *Injury*

The patient has never had major injuries.

iii. *Surgery*

He had a prostatectomy performed in 2014 and an arthroscopy of right knee was done in 2017.

iv. *Medical*

Major medical problems her has faced are: measles in childhood, at 14 years he had a meningoencephalitis tick, he was diagnosed with hypertension in 2013. In addition, in early 2014 he underwent Proton Therapy twice.

v. *Prior Rehabilitation*

Patient has done little rehab after arthroscopy of right knee. For the current problem he has not done anything, was waiting for surgery. He doesn't use any assistive devices.

vi. *Diet*

Patient has no special diet.

vii. *Allergens*

He presents with no allergens.

viii. *Abuses*

Patient is an occasional drinker.

ix. *Occupational*

He is an Hotelier.

x. *Hobbies*

Patient enjoys skiing and is generally quite active.

xi. *Family*

Patient is married with 3 children (all independent and healthy), he currently lives with his wife. His father had prostate cancer and his mother suffers from coronary heart disease and Diabetes Mellitus type 2.

2.4 Expert's Surgery report of the replacement

Surgery report – patient was under calm spinal anesthesia. A onetime grinding cut was done on the anterior aspect of knee joint and medially from patella. There was removed residue of meniscus and ACL, medial release at varosity. The scar is covered in a suture sterile cover without leakage.

2.5 Indication for Rehabilitation

According to MUDr.K. - Patient presented without redness or signs of environmental inflammation. He has regressive postoperative edema.

Hoping for a flexion of at least 90 degrees actively and an almost full extension. He should be walking (on crutches) by the 2nd day with only 20 – 30 percent loading on the operated leg.

2.6 Differential Balance

From the surgery we expect pain from the operated knee that results in the following: major reduction in the range of motion of the knee joint worst being extension in. Weakening mainly of quadriceps muscles, and mainly shortening of hamstrings. It is expected to find swelling and edema in the operated leg that also affects the functionality of the knee. Because the surgery caused a lot of movement of soft tissue in the anteromedial region of the knee, it is expected that the patient will experience most pain or irritation in this region.

2.7 Initial Kinesiological Examination

The initial examination was conducted two days after surgery (20/01/2020). Therefore only certain examinations can be done and others shall be left for later during the treatment sessions.

i. Aspection and Palpation

	Left	***Right***
Colour	Red/ pink	Normal
Skin	Stretched and tense: specifically from the area where the tibia begins to the area of entire knee joint and just above it.	Soft and free
	Inflamed due to edema. The swelling of the knee felt greatest around the knee joint itself and the popliteal area.	Normal knee shape: well contoured. Better tonus of quadriceps muscles.

Size/ shape	Quadriceps looked smaller or less contoured. The left calf looked slightly smaller.	Right calf slightly bigger than left.
Temperature	Warm temperature	Body temperature
Feeling during palpation	When Palpating patient felt pain on the medial side of the knee towards the medial epicondyle of the femur and on the middle of the lateral side of the knee when pressed deeper.	Nothing out of the ordinary.
Position	The left knee was rested in a more flexed position.	Not fully extended/ slightly flexed.

Table No.7: Aspection and Palpation of knee joint and adjecent areas (Initial exam)

ii. *Superficial sensations of the Lower Extremity*:

Light touch using hands through the dermatomes in the lower extremity testing for sensitivity of patient. Patient reports what he feels:

All normal on the right.

Left leg medially, ventrally and posteriorly all is normal but laterally from the lower thigh to beginning of upper leg he feels "numb": he says he feels the touch but in a dull manner.

iii. Circumference

	Left cm	***Right cm***
Ankle	30	30
Knee	53	44
Calves	41	42
Thigh	Lower: 52 Upper: 50	Lower: 47 Upper: 52

Table No.8: Circumference of Lower Extremity (initial exam)

iv. Range of motion

Knee:

	Left	***Right***
Flexion, Extension	Active: S: 0-10-30 Passive: S: 0-10-55	Active: S: 0-5-110 Passive: S: 0-5-120

Table No.9: Knees range of motion (Initial exam)

Left Knee: was at 10 degrees as the starting position. It was painful to get to the passive 0 degrees of extension. The patient was able to obtain 30 degree flexion with the pain actively.

When doing active motion, in flexion patient felt pain in the vastus medialis and rectus femoris region.

When passively flexing his knee he felt an intense stretch on the middle of the entire thigh but mostly focused towards the knee.

Ankle:

	Left	***Right***
Dorsiflexion/Plantarflexion	Active S: 10 -0 - 45 Passive S: 20 -0 - 45	Active: S: 20 -0 - 45 Passive S: 20 -0 - 50
Eversion/Inversion	Active R: 30 -0 - 35 Passive R: 30 -0 - 40	Active: R: 30 -0 - 30 Passive R: 30 -0 – 35

Table No.10: Ankle range of motion (Initial exam)

Hip: flexion on left side done with knee flexed.

	Left	***Right***
Extension/Flexion	Active S: 10 -0 – 30 Passive S: 10 -0 - 80	Active S: 10 -0 - 60 Passive S: 10 -0 - 85
Abduction/Adduction	Active F: 45 -0 - 20 Passive F: 50 -0 - 30	Active F: 45 -0 - 30 Passive F: 50 -0 - 30
External/Internal Rotation	Active R: 35 -0 - 25 Passive R: 45 -0 - 30	Active R: 45 -0 - 40 Passive R: 45 -0 -45

Table No.11: Hip FLX on left side with knee flexed (Initial exam)

v. Muscle Length Test:

	Left	***Right***
Hamstrings – acc. Kendall	55degrees	70degrees
Hip flexors – acc. Kendall	shortness in two joint muscles plus stretching pain felt at on the anterior thigh	shortness in two joint muscles plus stretching pain felt at on the anterior thigh
Triceps Surae – acc. to Janda	*Grade 1*	*Grade 0*

Table No.12: Muscle length test (initial exam)

vi. Muscle Strength Test according to Kendall:

	Left	***Right***
Quadriceps Femoris	Grade -3 he can make the movement but can't hold or resist pressure.	Grade 8
Iliopsoas	Grade 5 he can hold the hip flexion but with slight pressure	Grade 7
Hip Adductors	Grade 5 he can move against slight pressure but adding a bit more pressure he starts to feel pain throughout the movement.	Grade 7
Gluteus Medius	Grade 5 he can move against slight pressure but adding a bit more pressure he starts to feel pain.	Grade 8
Gluteus Minimus	Grade 5 he can move against slight pressure but adding a bit more pressure he starts to feel pain.	Grade 8
Tensor Fascia Latae	Grade 5 he can move against slight	Grade 8

	pressure but adding a bit more pressure he starts to feel pain.	
Medial and Lateral Rotators of Hip	Grade 7 he can do the positions against moderate pressure more pressure and he begins to feel pain in the knee joint.	Grade 7
Hamstrings	Grade 4 he can hold the text position, but cannot when pressure is added	Grade 8
Gastrocnemius	Grade 6: he can hold the position against slight-moderate pressure	Grade 8

Table No.13: Muscle Strength test acc.Kendall (Initial exam)

vii. Gait:

Patient was using crutches. He is using the three point gait. He walks with an upright posture, there isn't much motion in the left knee. He is only allowed 30 percent loading. Patient is yet to try staircase walking.

2.7.1 Conclusion of Initial Kinesiological Examination

Patient is healing quite well given it is 2nd day after surgery meaning there are no complications. Patient is presenting with weak and taught quadriceps which also limits or prohibits knee extension.

He also has shortened hamstrings hence the natural flexed position of his knees which will affect his gait as it as his knee will not extent fully. The patient lacks in further knee flexion due to weakness of the hamstrings, resulting in no further knee flexion during gait.

As reflected by the circumferences measured of the lower extremities, the patient has a significantly increased level of oedema in the knee caused by the trauma to the soft tissues. This greatly affects the functionality and state of the knee joint. The circumferences also indicate the condition of the muscles. Comparing the right and left

thigh, the right thigh has a bigger diameter on the quadriceps, indicating muscle atrophy in the left leg possibly due to lack of use.

On the other hand, the loss of normal sensation on the lateral side of knee (around L2-L3 dermatomes) seems normal after the surgery and given the state of his soft tissues.

Looking at the mobility of the hip and ankle, patient does not show any major pathological signs. He is not very flexible in these joints but it he still in the norm with exception of hip flexion which is shortened by the tight hamstrings, but on the left leg he can poorly raise the leg actively due to muscle weakness of the hip flexors.

2.8 Physiotherapy Plan

i. Short term physiotherapy plan:

- To reduce edema around the knee and surrounding tissue.
- To restore optimal range of motion in the knee joint in both flexion and extension.
- To reduce the tightness and increase the length in knee extensors and to strengthen them.
- To release the tight hamstrings.
- To regain stability in knee and core
- To educate on staircase walking on crutches.

ii. Long term physiotherapy plan:

NOTE: when patient is in a less acute condition, I would like to do a postural examination and deep stabilization examination. From those outcomes I would work on the following:

- Gait pattern of patient.
- Stability of the knee joint functionally
- Exercises of the deep stabilization system as it will affection his static and functional postures which in turn have an effect on the knee joint.
- As his scar is still covered for the period I have with him, I would like to work on scar tissue in the long run.
- As patient suffers from Bilateral Gonarthritis I would like to start on conditioning of the right knee. #

2.9 Physiotherapy Process

DAY ONE: 20/01/2020

Subjective: from a general perspective, besides the knee situation, patient is feeling quite healthy. He is feeling pain in quads and describes it as muscle pain. He is feeling a weird sensation on the lateral side of the knee. Patient is complaining that he cannot raise his leg actively.

Objective: patient is very enthusiastic to start therapy. Patient is cognitive and in a good mental state. Patient's scar is still covered but you can tell there are no other issues such as an infection or bleeding around the scar or knee. He is only allowed 30% loading on treated leg at most. Patient is failing to extend the knee actively and lifting the leg without help is almost impossible.

Goal of today's therapy unit:

- To release soft tissues and skin.
- To stimulate the superficial sensations on the lateral side of the knee.
- To improve ROM in extension and flexion and to strengthen the muscles surrounding the knee for stability of the joint.
- Lastly the goal is to stretch the tight muscles.

Proposed therapy:

- Soft tissue techniques for skin and scar.
- Mobilization techniques.
- Strengthening exercises- using isometric contractions.
- Basic stretching of quadriceps femoris.
- Post isometric relaxation and reciprocal inhibition of hamstrings.

Procedure:

- Soft tissue techniques using soft ball, then spiky ball to increase sensation on the left leg for 5mins. Concentrated on the knee.
- Classical massage on the anterior side of upper lower extremity. Gentle massage around the knee.
- Passive motions of knee; flexion and extension

- Active exercises focusing on left leg:
    - Patient lying supine: Rolling of soft ball to barrier allowing flexion in the knee and hip [10 counts].
    - Patient lying supine: Placing of soft ball under left knee patient then attempts to extend the knee. This exercise was active-assistive [10 counts].
    - Patient lying supine: Placing of soft ball between patient's flexed knees and patient performs adduction [10 counts].
    - Side lying stretch of quadriceps on left leg. Fixation of pelvis very mandatory. There is support of the lower leg by the knee (like carrying a baby).
    - In prone position: patient flexes the knee first passively then active-assistive till barrier reached or when patient feels uncomfortable [10 counts].
    - Lastly patient does the bridge dynamically. I was supporting/ fixating the position by fixing the feet. [10 counts].

Result of therapeutic unit:

Overall the patient was quite enthusiastic about therapy and he was participating during all the exercises with maximum effort.

Patient found it extremely difficult to extend and flex the knee actively and he still slightly struggled from pain during active-assistive movements.

During adduction patient felt pain on the lower medial side of the thigh (around vastus medialis).

Patient enjoys the stretch of the quadriceps.

Self-treatment:

Practicing flexion and extension while sitting at the edge of the bed, right leg behind the left during flexion and vice-versa during extension. [10 counts each direction].

DAY TWO: 21/01/2020

Subjective: at a general point of view, patient feels healthy. He still feels uncomfortable pain in quadriceps and still cannot extend the leg. Patient is still complaining about the unusual feeling during superficial touch on lateral knee. Passive motion with CPM machine is now 60degrees of flexion.

Objective: patient is very cognitive and enthusiastic. He has no other rising problems. His scar is still covered and knee still inflamed due to edema. Passive extension of left leg is no longer too painful.

Goal of today's therapeutic unit:

- To release soft tissues and skin.
- To stimulate the superficial sensations on the lateral side of the knee.
- To improve ROM in extension and flexion and to strengthen the muscles surrounding the knee for stability of the joint.
- Lastly the goal is to stretch the tight muscles.

Proposed therapy:

- Soft tissue techniques for skin and scar.
- Mobilization techniques
- Strengthening exercises.
- Stretching techniques

Procedure (same parameters as day one):

- Soft tissue techniques using soft ball, then spiky ball to increase sensation on the left leg.
- General massage on the anterior side of upper lower extremity. Gentle massage around the knee.
- Stretching of hip flexors and knee extensors.
- Passive motions of the knee; flexion and extension
- Active exercises focusing on left leg:
    - Patient supine: Ankle pumps (dorsiflexion and anteflexion of the ankle)
    - Flexion of knee and hip by guiding the oval ball as far as possible.

- Knee extension with towel under the knee (first he attempts actively then active-assistive)
- Straight leg raise.
- Adduction of lower extremities with knees bent and oval ball between the knees.

Results of therapeutic unit:

Again patient was very enthusiastic and fully participating.

Active adduction on oval ball feels painful around medial epicondyle.

Straight leg, patient cannot do it actively, therefore it was done with active-assistive motion.

Self-Treatment:

Practicing flexion and extension while sitting at the edge of the bed, right leg behind the left during flexion and vice-versa during extension. [10 counts each direction].

DAY THREE: 22/01/2020

Subjective: patient is feeling generally good. Although he feels an increase in pain or sensitivity to the pain in the left knee during flexion as compared to previous session. He feels weakness in thighs after strong exercises. The pain is mainly on the medial side.

Objective: patient again looks well and eager for the session. He still is lacking superficial sensation on the lateral aspect of the knee. He is more tolerate to the left knee extension passively and actively. The skin around is knee is still rigid and stretched out. Soft tissues surrounding the knee are still restricted. He feels most pain on and around the medial and lateral epicondyle of the knee. Patient has 60degrees of knee flexion active movement and can do active flexion of knee with resistance (less resistant as he flexes and more as he extends).

Goal of today's therapeutic unit:

- To release soft tissues and skin.
- To stimulate the superficial sensations on the lateral side of the knee.
- To improve ROM in extension and flexion by passive movements

- To strengthen the muscles surrounding the knee for stability of the joint.
- Lastly the goal is to stretch the tight muscles.

Proposed therapy:

- Soft tissue techniques for skin and scar.
- Mobilizations techniques
- Strengthening exercises.
- Stretching techniques and Post Isometric relaxation

Procedure (same parameters as day one):

- Soft tissue techniques using soft ball, then spiky ball to increase sensation on the left leg.
- General massage on the anterior side of upper lower extremity. Gentle massage around the knee.
- Passive motions of knee
- Stretching of hip flexors and knee extensors.
- PIR of hamstrings.
- Active exercises focusing on left leg:
    - Flexion of knee by guiding the oval ball as far as possible.
    - Knee extension with oval ball under the knee
    - Abduction and Adduction of straight left leg with slight resistance from Therapist.
    - Dynamic bridging.

Results of therapeutic session:

Patient was doing less number of repetitions as compared to the last session as he was feeling pain quite soon. But he put effort in all procedures.

The pain was felt in a sharp way on the medial side of knee.

Self-therapy:

To now practice straight leg raising as much as he can, and to continue with practicing flexion and extension while sitting at the edge of the bed, right leg behind the left during flexion and vice-versa during extension [10 counts each direction].

DAY FOUR: 23/01/2020

Subjective: patient is feeling the best he has been since the beginning of the therapy. The pain in his quadriceps is much less noticeable: the medial side is much less irritated. Patient still feels an odd sensation on the lateral knee. According to the CPM machine, patient can now passively flex his leg to 80º and fully extend to 0º.

Objective: gait pattern of patient has really improved: you can see the flexion and extension movements in the left knee. He also begins each step with a heel strike. When palpating his left leg/knee patient demonstrates less sensitivity to pain. The edema has reduced.

Goal of today's therapeutic unit:

- To release soft tissues and skin.
- To stimulate the superficial sensations on the lateral side of the knee.
- To improve ROM in extension and flexion using passive motions
- To strengthen the muscles surrounding the knee for stability of the joint.
- Lastly the goal is to stretch the tight muscles.
- To introduce stair walking.

Proposed therapy:

- Soft tissue techniques for skin and scar.
- Mobilization techniques
- Strengthening exercises.
- Stretching techniques
- Post Isometric relaxation

Procedure (same parameters as day one):

- Soft tissue techniques using soft ball, then spiky ball to increase sensation on the left leg, more focus on the knee region.
- General massage on the anterior side of upper lower extremity. Gentle massage around the knee.
- Passive motions of flexion and extension of knee.
- Stretching of hip flexors and knee extensors.
- PIR of hamstrings.
- Active exercises focusing on left leg:

- Patient supine: flexion of knee and hip by guiding the oval ball as far as possible.
- Patient supine: pressing into the oval ball from the heel allowing extension in knee
- Patient supine: Straight leg raising
- Patient supine: Abduction and Adduction of straight left leg with slight-moderate resistance from Therapist.
- Dynamic bridging.
- Gait: stairs walking.

Results of therapeutic session:

Patient was very cooperative with each exercise, he was in less pain during the exercises as compared to the other sessions,

Patient cannot do the straight leg raise easily, he raises it about 20 degrees without much of a struggle but cannot hold it or go higher.

Self- therapy:

Patient should continue working on raising his straight leg. Practicing flexion and extension while sitting at the edge of the bed, right leg behind the left during flexion and vice-versa during extension (10 repetitions in each direction).

DAY FIVE: 24/01/2020

Subjective: patient no longer feels pain in knee or areas close to knee when relaxed. He feels pain when barriers are reached during motions. The odd superficial sensations still persisted.

Objective: patient's soft tissues have decreased in swelling. Gait is beginning to look more natural. During palpation of the medial side of knee, there is less negative reaction from the patient. He feels no pain or discomfort during the palpation of his quadriceps. Slight pain/uncomfortable feeling on lateral side of knee.

Goal of today's therapeutic unit:

- To release soft tissues and skin.
- To stimulate the superficial sensations on the lateral side of the knee.
- To improve ROM in extension and flexion using passive motions.
- To strengthen the muscles surrounding the knee for stability of the joint.
- To stretch the tight muscles.

Proposed therapy:

- Soft tissue techniques for skin and scar.
- Mobilization techniques
- Strengthening exercises.
- Stretching techniques
- Post Isometric relaxation

Procedure:

- Soft tissue techniques using soft ball, then spiky ball to increase sensation on the left leg.
- General massage on the anterior side of upper lower extremity. Gentle massage around the knee.
- Passive movements of knee
- Stretching of hip flexors and knee extensors: using method of testing for muscle length of hip flexors. I then apply dorsal pressure on the knee, followed by dorsal pressure at lower limb. Can be down simultaneously or separately.
- PIR of hamstrings.
- Active exercises focusing on left leg:
    - Flexion of hip and flexion – extension of knee at the same time [6 counts].
    - Extension of knee with oval ball under [10 counts].
    - Abduction and adduction with knees flexed using resistant band and oval ball [10 counts 2 reps].
    - Dynamic hip bridge [10 counts hold position on the last].
    - Static Hip-bridge while passing ball under [10 times ball passes].

Results of therapeutic session:

Patient is getting stronger – can raise straight leg higher and hold against slight resistance. Flexion and extension of knee are possible for patient to perform against slight resistance. Patient still feels his hamstrings as tight.

Self-therapy:

Patient should continue working on raising his straight leg as much as possible. Practicing flexion and extension while sitting at the edge of the bed, right leg behind the left during flexion and vice-versa during extension (10 repetitions in each direction).

DAY SIX: 27/01/2020

Subjective: patient is feeling quite sensitive, he is feeling pain more during movement more than the last session. He says it is caused by him over training it. Still has the same odd sensation on the lateral side of left leg.

Objective: edema had increased as compared to last session. Patient was more sensitive during palpation.

As the patient was in an acute state during the initial kinesiological examination, there was no opportunity to examine his posture. Therefore in this session, examination of the posture was done.

Postural Examination:

Anterior view:

Feet – left and right foot both have moderately collapsed arches. Therefore patient is slightly flat footed on both feet. Right foot is turned moderately more outward than left.

Calves – left and right knees have the same contour size (same tonicity).

Knees – right knee's patella is slightly facing outward. Both knees are positioned as the same level.

Torso – patient leans more towards the right.

Shoulders – the right shoulder is higher than the left.

Head – is centered.

Posterior View:

Feet – left and right foot Achilles have the same shape. Right medial malleolus is collapsing inside. Right foot is turned moderately more outward than left. Left foot's heel is not in much contact with the ground as the right.

Calves – left and right knees have the same contour size/shape (same tonicity).

Knees – Left knee's popliteal is higher compared to the right.

Torso – patient leans more towards the right.

Shoulders – the right shoulder is higher than the left, putting the right scapula at a higher position than left.

Head – is centered.

Lateral view left:

Feet – left foot points straight forward and the heel is very slightly off ground.

Calves – left and right knees have the same contour size/shape (same tonicity).

Knees – Left knee is slightly-to moderately flexed or not in full extension.

Torso – patient leans more towards the right. There is moderate kyphosis in the upper thoracic. Patient also has a flat back.

Shoulders – the left shoulder is lower than the left. You can also observe moderate protraction of the shoulders.

Head – is centered but patient has a moderate forward head posture.

Lateral view right:

Feet – right foot points moderately outwards and the entire foot is in full contact with the ground.

Calves – left and right knees have the same contour size/shape (same tonicity).

Knees – Right knee is in a very slight extension.

Torso – patient leans more towards the right. There is moderate kyphosis in the upper thoracic. Patient also has a flat back.

Shoulders – the right shoulder is higher than the left. You can also observe moderate protraction of the shoulders.

Head – is centered but patient has a moderate forward head posture.

Pelvic examination:

There is a pelvic tilt to the left (right pelvis is higher than left).

Spine sign test – there is no blockage in the SI joint on both right and left side.

Dynamic spine examination:

Anteflexion – patient is not showing a natural curving motion. He rounds the shoulders and flexes the neck, and continues movement from the pelvis. There is slight flexion in the thoracic spine but the lumbar is quite straight.

Retroflexion – patient is able to perform the movement. His lumbar spine shows no extension, his lower thoracic shows extension but the upper thoracic remains straight or in slight flexion. The cervical spine extends.

Lateroflexion – right: patient is able to do the motion without complaints. He feels a stretch of muscles on the left side. His lumbar spine and lower thoracic show slight curvature. Meanwhile the upper thoracic and cervical spine are curving according to the movement.

Left: patient is able to do the motion without complaints. He feels a stretch of muscles on the right side. His lumbar spine and lower thoracic show more of a curve as compared to the right. Upper thoracic and cervical spine are curving. Unlike the right side, patient is showing a slight rotation with the side-bending.

Conclusion of examinations:

According to the examinations, patient has problems such as flat foot, and misalignment of the foot positioning (right being further out). He also has imbalances as reflected by the tilt of his torso. According to the dynamic spine examination patient does have blocked joints in the lumbar, thoracic and slightly in the cervical spine. These pathologies are important to consider especially with the case of the patient.

In relation to Kinesiology a problem found in one these structures affects the condition of the other structures; pathologies reflected in the patient's feet, pelvis and spine influence the conditions of the knee (functionally and structurally). For the patient to reach the optimal condition after his total knee replacement, there should be corrective methods used to restore the physiological states in the pathological structure.

Long term therapy proposal:

The main purpose of the long term therapy would be the correction of the patient's posture. This will be done by the following:

- Strengthening of deep muscles of the foot as he is flat footed.
- To improve mobility in ankle joint.
- To correct imbalances of soft tissue and muscles on the back.
- To improve mobility of the blocked spinal segments.
- Improvement of deep stabilization system

These therapy proposals would be implemented when the patient gets out of the acute phase.

Goal of today's therapeutic unit:

- To release soft tissues and skin.
- To stimulate the superficial sensations on the lateral side of the knee.
- To improve ROM in extension and flexion of the knee
- To strengthen the muscles surrounding the knee for stability of the joint.
- To stretch the tight muscles.
- Work on deep stabilization system

Proposed therapy:

- Soft tissue techniques for skin and scar.
- Mobilization
- Strengthening exercises.
- Stretching techniques
- Post Isometric relaxation

Procedure [same parameters as last session]:

- Soft tissue techniques using soft ball, then spiky ball to increase sensation on the left leg.
- General massage on the anterior side of upper lower extremity. Gentle massage around the knee.
- Stretching of hip flexors and knee extensors in the same way as last session.
- Passive motions of the knee joint
- PIR of hamstrings.
- Active exercises focusing on left leg:
    - Flexion of hip and flexion to extension of knee at the same time.
    - Extension of knee with oval ball under.
    - Abduction and adduction with knees flexed using oval ball and resistance band.
    - Dynamic hip bridge.
    - Static Hip-bridge while passing ball under.

Results of therapeutic unit:

Patient was very sensitive to pain during the session therefore the amount of active exercises were performed with fewer repetitions and intensity as compared to the last session.

Self -Therapy:

Patient should work on raising his straight leg and after 3 times hold for 5-7 seconds. Practicing flexion and extension while in prone position (10 counts, 3 sets).

DAY SEVEN: 28/01/2020

Subjective: patient feels less sensitive to pain as compared to last time. Feels as though his muscles are stronger.

Objective: patient is in a better condition physically compared to the last time. The swelling around the knee decreased moderately compared to the last session.

Goal of today's therapeutic unit:

- To release soft tissues and skin.
- To stimulate the superficial sensations on the lateral side of the knee.
- To improve ROM in extension and flexion of the knee
- To strengthen the muscles surrounding the knee for stability of the joint.
- To stretch the tight muscles.
- Work on deep stabilization system

Proposed therapy:

- Soft tissue techniques for skin and scar.
- Mobilization
- Strengthening exercises.
- Stretching techniques
- Post Isometric relaxation

Procedure:

- Soft tissue techniques using soft ball, then spiky ball to increase sensation on the left leg.
- General massage on the anterior side of upper lower extremity. Gentle massage around the knee.
- Stretching of hip flexors and knee extensors.
- Passive motions of the knee joint
- PIR of hamstrings.
- Active exercises focusing on left leg
    - Patient supine: Flexion of hip and flexion to extension of knee at the same time [6 tcounts].
    - Patient supine: Extension of knee with oval ball under [10 counts].

- Abduction and adduction with knees flexed using oval ball and resistance band [10 counts 2reps].
- Dynamic hip bridge [10 counts].
- Static Hip-bridge while passing ball under [10 counts].
- With a big a ball supporting his lower extremities, patient should try to maintain a flat back and tap opposite knee to opposite arms [6 counts].

Results of therapeutic session:

Patient was more tolerable to the active exercises as compared to the last session. During PIR of hamstrings patient reached a new barrier. He was able to perform basic active motions of hip and knee with slight resistance.

Self-therapy:

Patient should work on raising his straight leg and after 3 times hold for 5-7 seconds. Practicing maintaining a flat back with lower extremities flexed up.

DAY EIGHT: 28/01/2020

Subjective: patient was feeling good about his physical condition more specifically his knee. He was feeling less pain as compared to the last sessions.

Objective: patient still has his scar closed as requested by the doctor. While palpating his skin, there was more freedom in movement and elasticity as compared to the previous sessions. Patient is obtaining a more optimal gait pattern.

Goal of today's therapeutic unit:

- To release soft tissues and skin.
- To stimulate the superficial sensations on the lateral side of the knee.
- To improve ROM in extension and flexion of the knee
- To strengthen the muscles surrounding the knee for stability of the joint.
- To stretch the tight muscles.
- Work on deep stabilization system

Proposed therapy:

- Soft tissue techniques for skin and scar.
- Strengthening exercises.
- Stretching techniques
- Post Isometric relaxation

Procedure:

- Soft tissue techniques using soft ball, then spiky ball to increase sensation on the left leg.
- General massage on the anterior side of upper lower extremity. Gentle massage around the knee.
- Stretching of hip flexors and knee extensors.
- Passive motions of the knee joint
- PIR with stretching of hamstrings.
- Active exercises focusing on left leg
    - Patient supine: Flexion of hip and flexion to extension of knee at the same time [8 counts].
    - Patient supine: Extension of knee with oval ball under [10 counts].
    - Abduction and adduction of extended lower extremities using slight resistance [10 counts].
    - Dynamic hip bridge with resistance band around the knee [10 counts].
    - Static Hip-bridge while passing ball under [10 counts].
    - With a big a ball supporting his lower extremities, patient should try to maintain a flat back and tap opposite knee to opposite arm [10 counts].

Results of therapeutic session:

Patient was performing all the active exercises well. He felt more relaxation of his hamstrings today. He found the stabilization exercises quite exhausting. He did not feel much muscle pain in this session.

Self-therapy:

Practicing maintaining a flat back with lower extremities flexed. Patient should do flexion of hip and flexion to extension of the knee at the same time. When knee is extended patient should hold position for 5-7 seconds and repeat 3 times.

DAY NINE: 29/01/2020

Subjective: patient feels as though he is improving in terms of strength in his leg, but he feels the same level of pain or discomfort. There is still issues with sensitivity on the lateral side of the knee.

Objective: patient's swelling has gone down evidently. Scar is still closed and when palpating around the knee, the patient isn't reacting negatively to the palpation on the medial side of the knee.

Goal of today's therapeutic unit:

- To release soft tissues and skin.
- To stimulate the superficial sensations on the lateral side of the knee.
- To improve ROM in extension and flexion of the knee
- To strengthen the muscles surrounding the knee for stability of the joint.
- To stretch the tight muscles.
- Work on deep stabilization system

Proposed therapy:

- Soft tissue techniques for skin and scar.
- Strengthening exercises.
- Stretching techniques
- Post Isometric relaxation

Procedure [same parameters as last session]:

- Soft tissue techniques using soft ball, then spiky ball to increase sensation on the left leg.
- General massage on the anterior side of upper lower extremity. Gentle massage around the knee.

- Stretching of hip flexors and knee extensors.
- Passive motions of the knee joint
- PIR with stretching of hamstrings.
- Active exercises focusing on left leg
    - Flexion of hip and flexion to extension of knee at the same time.
    - Extension of knee with oval ball under.
    - Abduction and adduction of extended lower extremities using moderate resistance.
    - Dynamic hip bridge with resistance band around the knee.
    - Static Hip-bridge while passing ball under and over.
    - With a big a ball supporting his lower extremities, patient should try to maintain a flat back and tap opposite knee to opposite arm [10 counts].

Results of therapeutic session:

Patient is actually much stronger, he can with stand an increase in resistance during active motions. He reacts less negatively when barriers are reached during passive motions.

Self-treatment:

Practicing maintaining a flat back with lower extremities flexed. Patient should do flexion of hip and flexion to extension of the knee at the same time. When knee is extended patient should hold position for 5-7 seconds and repeat 3 times.

DAY TEN: 30/01/2020

Subjective: patient feels "better than ever", the discomfort in knee when relaxed is barely noticeable. When walking there is a slight pain when he tries to do the proper gait pattern perfectly. According to the doctor patient can start practicing 50% loading on the operated leg.

Objective: patient is still using crutches, but his gait is looking quite good, only a little slower in pace. The patient's scar is still covered as requested by the doctor.

This was the last session with the patient, therefore a Final Kinesiological examination was done.

2.10 Final Kinesiological Examination

i. Postural Examination:

Anterior view:

Feet – left and right foot both have moderately collapsed arches. Therefore patient is slightly flat footed on both feet. Right foot is turned moderately more outward than left.

Calves – left and right knees have the same contour size (same tonicity).

Knees – right knee's patella is slightly facing outward. Both knees are positioned as the same level.

Torso – patient leans more towards the right.

Shoulders – the right shoulder is higher than the left.

Head – is centered.

Posterior View:

Feet – left and right foot Achilles have the same shape. Right medial malleolus is collapsing inside. Right foot is turned moderately more outward than left. Left foot's heel is not in much contact with the ground as the right.

Calves – left and right knees have the same contour size/shape (same tonicity).

Knees – Left knee's popliteal is slightly higher compared to the right.

Torso – patient leans more towards the right.

Shoulders – the right shoulder is higher than the left, putting the right scapula at a higher position than left.

Head – is centered.

Lateral view left:

Feet – left foot points straight forward and the foot is in full contact with the ground.

Calves – left and right knees have the same contour size/shape (same tonicity).

Knees – Left knee is slightly flexed or not in full extension.

Torso – patient leans more towards the right. There is moderate kyphosis in the upper thoracic. Patient also has a flat back.

Shoulders – the left shoulder is lower than the left. You can also observe moderate protraction of the shoulders.

Head – is centered but patient has a moderate forward head posture.

Lateral view right:

Feet – right foot points moderately outwards and the entire foot is in full contact with the ground.

Calves – left and right knees have the same contour size/shape (same tonicity).

Knees – Right knee is in a very slight extension.

Torso – patient leans more towards the right. There is moderate kyphosis in the upper thoracic. Patient also has a flat back.

Shoulders – the right shoulder is higher than the left. You can also observe moderate protraction of the shoulders.

Head – is centered but patient has a moderate forward head posture.

ii. Pelvic examination:

There is a pelvic tilt to the left (right pelvis is higher than left).

Spine sign test – there is no blockage in the SI joint on both right and left side.

iii. Dynamic spine examination:

Anteflexion – patient is not showing a natural curving motion. He rounds the shoulders and flexes the neck, and continues movement from the pelvis. There is slight flexion in the thoracic spine but the lumbar is quite straight.

Retroflexion – patient is able to perform the movement. His lumbar spine shows no extension, his lower thoracic shows extension but the upper thoracic remains straight or in slight flexion. The cervical spine extends.

Lateroflexion – right: patient is able to do the motion without complaints. He feels a stretch of muscles on the left side. His lumbar spine and lower thoracic show slight curvature. Meanwhile the upper thoracic and cervical spine are curving according to the movement.

Left: patient is able to do the motion without complaints. He feels a stretch of muscles on the right side. His lumbar spine and lower thoracic show more of a curve as compared to the right. Upper thoracic and cervical spine are curving. Unlike the right side, patient is showing a slight rotation with the side-bending.

iv. Aspection and Palpation of the knee joint and surrounding areas:

	Left	***Right***
Colour	Normal with slight redness in patches.	Normal
Skin	Moderately stretched and tense closer to the scar, and further away the tension releases.	Soft and free
Size/Shape	Inflammation has markedly reduced around the knee joint. Quadriceps look slightly more contoured meanwhile the calf remains the same.	Normal knee shape: well contoured. Better tonus of quadriceps muscles. Right calf slightly bigger than left.

Temperature	Still warmer as compared to the right.	Body temperature
Feeling during palpation	Patient felt discomfort when palpating the medial side of knee with normal pressure and sharp pain when medial epicondyle was pressed. The lateral side of knee he felt only discomfort. He felt irritation when pressing close to the scar.	Nothing out of the ordinary.
Position	The leg was rested in a slightly flexed position. More than the right side.	Not fully extended/ slightly flexed.

Table No.14: Aspection and Palpation of the knee joint and adjecent areas (Final exam)

v. *Superficial sensations of the Lower Extremity*:

Light touch using hands through the dermatomes in the lower extremity testing for sensitivity of patient. Patient reports what he feels:

All normal on the right.

Left leg medially, ventrally and posteriorly all is normal but laterally from the lower thigh to beginning of upper leg he feels "numb" he says he feels it but in a dull manner.

vi. Circumferences:

	Left	***Right***
Ankle	30	30
Knee	47	44
Calves	42	42
Thigh	Lower: 50 Upper: 51	Lower: 47 Upper: 52

Table No.15: Circumference of Lower extremity (Final exam)

vii. Range of motion:

Knee:

	Left	***Right***
Flexion, Extension	Active: S: 0 -5 -80 Passive: S: 0 -5 -90	Active: S: 0 -5 -110 Passive: S: 0 -5 -120

Table No.16: Knee range of motion (Final exam)

Left Knee: was at 5 degrees as the starting position. Patient did not feel pain during passive extension or flexion movements, he only felt pain during passive flexion of left leg when barrier was reached.

He did no complain of pain during active movement as before in the knee structures or muscles.

When passively flexing his knee there was a pleasurable stretch of quadriceps Femoris.

Ankle:

	Left	***Right***
Dorsiflexion/Plantarflexion	Active S: 10 -0 - 45 Passive S: 20 -0 - 45	Active: S: 20 -0 - 45 Passive S: 20 -0 - 50
Eversion/Inversion	Active R: 30 -0 - 35 Passive R: 30 -0 - 40	Active: R: 30 -0 - 30 Passive R:30 -0 - 35

Table No.17: Ankle range of motion (Final exam)

Hip:

	Left	***Right***
Extension/Flexion	Active S: 10 -0 – 80 Passive S: 10 -0 - 100	Active S: 10 -0 - 100 Passive S: 10 -0 - 110
Abduction/Adduction	Active F: 45 -0 - 20 Passive F: 50 -0 - 30	Active F: 45 -0 - 30 Passive F: 50 -0 - 30
External/Internal Rotation	Active R: 35 -0 - 25 Passive R: 45 -0 - 30	Active R: 45 -0 - 40 Passive R: 45 -0 -45

Table No.18: Hip range of motion (Final exam)

viii. Muscle Length Test:

	Left	***Right***
Hamstrings – acc. Kendall	60º	70º
Hip flexors – acc. Kendall	Shortness in two joint muscles plus with slightly uncomfortable tension on the quadriceps femoris.	Shortness in two joint muscles plus stretching pain felt at on the anterior thigh
Triceps Suarae – acc. to Janda	*Grade 1*	*Grade 0*

Table No.19: Muscle length test (Final exam)

ix. Muscle Strength Test according to Kendall:

	Left	***Right***
Quadriceps Femoris	Grade 6 he can hold the testing position against gravity against moderate pressure	Grade 8
Iliopsoas	Grade 6 he can hold the testing position with moderate pressure.	Grade 7
Hip Adductors	Grade 6 he can hold position against slight pressure but when you apply moderate pressure he feels uncomfortable on the medial side of knee.	Grade 7
Gluteus Medius	Grade 7 he can hold position against moderate pressure.	Grade 8
Gluteus Minimus	Grade 7 he can hold position against moderate pressure.	Grade 8

Tensor Fascia latae	Grade 7 he can hold position against moderate pressure.	Grade 8
Medial and Lateral Rotators of hip	Grade 7 as he can do the positions against moderate pressure more pressure and he begins to feel pain in the knee joint.	Grade 7
Hamstrings	Grade 7 holds testing position against moderate pressure	Grade 8
Gastrocnemius	Grade 7 holds position against moderate pressure	Grade 8

Table No.20: Muscle strength test acc.Kendall (Final exam)

x. Gait:

Patient still using crutches. He is using the two point gait. He walks with an upright posture, he checks all the points in the gait pattern: there is clear flexion and extension in the knee now, his hip extension needs more work. He is allowed 50% loading.

2.10.1 Conclusion of Final Kinesiological Examination

Patient has not shown any obvious improvement in posture. His left pelvis is still lower as the knee is slightly flexed when standing. Patient's spine mobility is still the same: the anteflexion and retroflexion are the ones with the least physiological movement.

Aspection and palpation of the skin showed that the patient's swelling has reduced significantly and the tension of the skin is only noticeable closer to scar. The condition of the skin and soft tissue has allowed the patient to gain more mobility in the knee. Patient still has the slight tingling or numbness on the lateral side of the knee (around L2-L3 dermatomes) which is normal after surgery and with swelling. Pain on when adding pressure to the knee has significantly decreased.

Patient's muscle strength has significantly improved: giving better control in the knee joint, especially during movement as his range of motion is increased. Also

strengthening of the muscles surrounding knees results in better stability of the joint, which is important for more demanding activities in the later stage of his rehabilitation.

He also has shortened hamstrings hence the natural flexed position of his knees which will affect his gait as it as his knee will not extent fully. The patient lacks in further knee flexion due to weakness of the hamstrings, resulting in no further knee flexion during gait.

Looking at the mobility of the hip and ankle, patient does not show any major pathological signs. He has improved the ROM* in his hip joint as his hamstrings have improved in length.

2.10.2 Evaluation on effectiveness of the therapy

From a general point of view, the patient has positively reacted to the short therapy sessions we had, focused on recovery of his recently operated left knee. This indicates that the therapeutic methods implemented were effective.

The patient still faced issues of discomfort upon palpation on the medial side of the knee; but the pain had significantly reduced compared to the beginning. This is quite normal in reference to the method of the surgery itself.

Edema can be a limiting factor in ROM. Initially the patient had quite a large swelling in soft tissues around the knee and nearing areas. His left initial knee circumference was 52.5 and in the final examination it became 47.5 which was quite close the right knee circumference (44.3). This shows there was improvement in edema.

It is clear that from the start the patient's knees have never reached 0^o extension at rest, (the left being in higher flexion due to surgery). Comparing the initial and final degrees of flexion (10^o and 5^o respectively) of left knee one can clearly see the improvement in the joint. This also indicates that there was an improvement in joint mobility which can be confirmed by the range on motions. Initially the patient had 0^o extension and 55^o flexion passively and actively he achieved 0^o extension and 30^o flexion; meanwhile the final examination showed 0^o extension and 90^o flexion passively and actively he achieved 0^o extension and 80^o flexion.

According to the results shown in the muscle strength test, patient showed a very great improvement. All muscles tested improved from not functioning with resistance to

being able to withstand resistance (slight – moderate). This is a very important achievement as it results in good joint stability, which is one of the goals of the rehabilitation.

Another positive outcome was the gait pattern of the patient. Started with a very antalgic gait pattern, using a 3 point crutches pattern. There was no clear motion in foot of heel strike – toe off, his left knee was fixed in flexion and lastly his hips showed little to no extension and flexion. Looking at the final kinesiological results, patient's gait was much faster (2 point crutches patter). He showed clear motion of the foot, his knee was flexing and extending and so was hip (although he could work on better hip extension).

Although there are many positive outcomes that came from these therapeutic sessions, some results did not respond well to them. The odd sensation on the lateral side of the left knee had not improved much which could be of concern at this stage, but it is not limiting the patient in any form.

The patient initially presented with shortened hamstrings (55^{o}) and after therapy the degree increased to 60^{o}: this is an improvement but his hamstring is still considered shortened according to Kendall's grading. A shorted hamstring long term wise could possibly result in blockage of fibular head, a fixed flexed position of the knee which in turn stresses the antagonistic muscles (development of trigger points or taut bands) which would also cause pain of the patella. This position could also put the anterior cruciate ligament in a vulnerable position.

Postural and Dynamic examination showed no difference from the initial test and the final. This is because the pathologies discovered where never addressed during the therapy sessions. Patient was in an acute stage after knee surgery, therefore it is something I would like to address in long term (when he is less dependent on crutches). It is very important to correct the posture as the condition of one segment of the body affects the function on the rest of the body.

The deep stabilization system is a component I haven't tested but is important to implement. This was due to a matter of time and acuteness of the patient. However, it remains an important component to include in exercising sessions in order to address the whole clinical picture (as it is big component in movement). In an ideal situation, I would work with the DSS* during dynamic exercises involving the whole body which would be done in the long term sessions.

3. Conclusion

All in all I believe the therapy performed was a success. The first encounter with the patient he was quite dependent but very eager to heal, by the time of his discharge he was very independent and ready to go back to his life.

This case study has truly reflected the importance of one's determination to get physically well. In ten days, at his age, the patient was remarkably doing well and from his enthusiasm will continue to progress.

4. Bibliography

1. Aaron, C. (2017, December 22). The Patella. Retrieved May 11, 2020, from https://teachmeanatomy.info/lower-limb/bones/patella/
2. Andme26. (2015, March 16). Anatomy of the knee (Bones Muscles Arteries Veins Nerves). Retrieved May 12, 2020, from https://hubpages.com/education/Anatomy-of-the-knee-Bones-Muscles-Arteries-Veins-Nerves
3. Bak, J., Shim, S., Cho, M., & Chung, Y. (2017). The Effect of Plank Exercises with Hip Abduction Using Sling on Trunk Muscle Activation in Healthy Adults. The Journal of Korean Physical Therapy, 29(3), 128–134. doi: 10.18857/jkpt.2017.29.3.128
4. BoneSmart. (n.d.). Types of Total Knee Implants. Retrieved from https://bonesmart.org/knee/types-of-total-knee-implants/
5. Bozic, K. (2018, June 9). Total Knee Replacement Risks and Complications. Retrieved May 22, 2020, from https://www.arthritis-health.com/surgery/knee-surgery/total-knee-replacement-risks-and-complications
6. Brotzman, B. S. MD., (2017, February 23). Patellofemoral Disorders. Retrieved May 20, 2020, from https://reader.elsevier.com/reader/sd/pii/B9780323393706000561?token=0EB467B3417774BC6D7CC9ACC6BB01BCD8E0548AEC21DADE21BC6F3537DCE1193332B2F3466465F10C6A4E8D9B644903
7. Brugioni, D. J., & Falkel, J. (2004). Getting Ready: Preparing your home and yourself for surgey. In Total Knee Replacement and Rehabilitation: The Knee Owner's Manual (1st ed., pp. 33–50). Alameda, CA: Hunter House Inc. Retrieved from https://books.google.cz/books?hl=en&lr=&id=soqBVfoRwu4C&oi=fnd&pg=PR11&dq=Brugioni, D., & Falkel, J. (2004). Total knee replacement and rehabilitation.&ots=5UOMgW42Ea&sig=syie6wxU0Nkd_MEG7EMrQKpiL0w&redir_esc=y#v=onepage&q=Brugioni, D., & Falkel, J. (2004). Total knee replacement and rehabilitation.&f=false
8. Burnham, J. (2019, June 16). Meniscus Tear Treatment: Knee Specialist: Baton Rouge, LA. Retrieved May 19, 2020, from https://www.jeremyburnhammd.com/arthroscopic-meniscus-surgery/
9. Chatra, P. S. (2012). Bursae around the knee joints. Indian Journal of Radiology and Imaging, 22(1), 27. doi: 10.4103/0971-3026.95400
10. Clinic, M. (2017, December 29). Knee replacement. Retrieved May 23, 2020, from https://www.mayoclinic.org/tests-procedures/knee-replacement/about/pac-20385276
11. Clinic, M. (2019, August 22). Hemophilia. Retrieved May 19, 2020, from https://www.mayoclinic.org/diseases-conditions/hemophilia/symptoms-causes/syc-20373327

12. Clinic, M. (2019, March 1). Gout. Retrieved May 19, 2020, from https://www.mayoclinic.org/diseases-conditions/gout/symptoms-causes/syc-20372897
13. Clinic, M. (2020, February 22). Osteoarthritis. Retrieved May 19, 2020, from https://www.mayoclinic.org/diseases-conditions/osteoarthritis/symptoms-causes/syc-20351925
14. Clinic, Q. K.-S. (2016, July 1). Physiotherapy after Total Knee Replacement (TKR). Retrieved May 24, 2020, from http://qldkneesurgery.com.au/physio-after-total-knee-replacement/
15. Davies, K. (2020, April 8). The Lumbar Plexus. Retrieved May 20, 2020, from https://teachmeanatomy.info/lower-limb/nerves/lumbar-plexus/
16. Delebarre, A. C., Bountry, N., Szymanski, C., Maynou, C., Lefebvre, G., Bellenger, E. A., & Cotten, A. (2016). Correlation between primary flat foot and lower extremity rotational misalignment in adults. In Diagnostic and Interventional Imaging (Vol. 97, pp. 1151–1157). Elsevier. doi: https://doi.org/10.1016/j.diii.2016.01.011
17. Doucette, S. A., & Child, D. D. (1996). The Effect of Open and Closed Chain Exercise and Knee Joint Position on Patellar Tracking in Lateral Patellar Compression syndrome. Journal of Orthopaedic & Sports Physical Therapy, 23(2), 104–110. doi: 10.2519/jospt.1996.23.2.104
18. Eladl, M. A. (2014, March 18). Anatomy of the Knee Joint. Retrieved May 12, 2020, from https://www.slideshare.net/maeladl/anatomy-of-the-knee-joint-32431921
19. Foran, J. R. H., & Fischer, S. J. (2017, February). Total Knee Replacement Exercise Guide - OrthoInfo - AAOS. Retrieved May 23, 2020, from https://orthoinfo.aaos.org/en/recovery/total-knee-replacement-exercise-guide/
20. Foundation, A. (n.d.). Rheumatoid Arthritis. Retrieved May 19, 2020, from https://www.arthritis.org/diseases/rheumatoid-arthritis
21. Fox, A. J. S., Bedi, A., & Rodeo, S. A. (2011). The Basic Science of Human Knee Menisci. Sports Health: A Multidisciplinary Approach, 4(4), 340–351. doi: 10.1177/1941738111429419
22. Goldblatt, J. P., & Richmond, J. C. (2005, January 11). Anatomy and biomechanics of the knee. Retrieved May 18, 2020, from https://www.sciencedirect.com/science/article/pii/1060187203800114
23. Greengard, S. (2017, December 20). Step-by-Step Explanation of Knee Replacement Surgery. Retrieved May 24, 2020, from https://www.healthline.com/health/total-knee-replacement-surgery-step-by-step
24. Hall, S. J. (2012). The Biomechanics of the Human Lower Extremity. In Basics of Biomechanics (6th ed., pp. 241–245). New York, NY: McGraw-Hill.
25. Healy, W. L., Wasilewski, S. A., Takei, R., & Oberlander, M. (1995). Patellofemoral complications following total knee arthroplasty. The Journal of Arthroplasty, 10(2), 197–201. doi: 10.1016/s0883-5403(05)80127-5

26. Holland, K. (2019, November 5). Stages of Osteoarthritis of the Knee. Retrieved May 21, 2020, from https://www.healthline.com/health/osteoarthritis-stages-of-oa-of-the-knee
27. Hopkins, J. (n.d.). Ligament Injuries to the Knee: Knee ligaments, Ligament injury, Anatomy of the knee. Retrieved May 11, 2020, from https://www.pinterest.cl/pin/708331847614546947/
28. Hughes, M. (2019, December 24). Diseases of Excessive Bone Growth. Retrieved May 19, 2020, from https://healthfully.com/diseases-of-excessive-bone-growth-4650884.html
29. Janghu, P. K. (2017, April 8). Knee Joint. Anatomy QA. Retrieved May 28, 2020, from http://anatomyqa.com/knee-joint-anatomy-important-question/
30. Janghu, P. K. (2018, May 21). Obturator Nerve, origin, root value, course and branches. Anatomy QA. Retrieved May 24, 2020, from https://anatomyqa.com/obturator-nerve-course-branches/
31. Joe, N. (2020, May 22). Popliteal artery. Retrieved May 28, 2020, from https://www.kenhub.com/en/library/anatomy/popliteal-artery
32. Jones, O. (2018, November 9). The Tibia. Retrieved March 20, 2020, from https://teachmeanatomy.info/lower-limb/bones/tibia/
33. Jones, O. (2018, May 2). Muscles in the Posterior Compartment of the Thigh. Retrieved April 30, 2020, from https://teachmeanatomy.info/lower-limb/muscles/thigh/hamstrings/
34. Jones, O. (2019, April 8). The Femur. Retrieved from https://teachmeanatomy.info/lower-limb/bones/femur/
35. Jones, O. (2020, April 20). Muscles in the Anterior Compartment of the Thigh. Retrieved April 30, 2020, from https://teachmeanatomy.info/lower-limb/muscles/thigh/anterior-compartment/
36. Jones, O. (2020, March 14). Muscles in the Medial Compartment of the Thigh. Retrieved April 30, 2020, from https://teachmeanatomy.info/lower-limb/muscles/thigh/medial-compartment/
37. Jones , S. G., Palmer, A. J. R., Agricola, R., Price, A. J., Vincent, T. L., Weinans, H., & Carr, A. J. (2015). Osteoarthritis. In The Lancet (Vol. 386, pp. 376–387). Elsevier. doi: https://doi.org/10.1016/S0140-6736(14)60802-3
38. Jr., W. C. S. (2019, November 27). Total Knee Replacement Recovery, Surgery Risks & Exercises. Retrieved May 19, 2020, from https://www.medicinenet.com/total_knee_replacement/article.htm
39. Kercher, J. (2019, April 22). Knee Replacement Surgery. Retrieved from https://www.webmd.com/osteoarthritis/guide/knee-replacement-surgery
40. Kinman, S. G. and T. (2020, April 27). After Total Knee Replacement: The Recommendations You Need to Follow. Retrieved May 23, 2020, from https://www.healthline.com/health/after-total-knee-replacement-surgery#follow-up

41. Knee replacement surgery orthopedic surgeon nairobi dr adari. (n.d.). Retrieved May 21, 2020, from https://www.orthobridgeorthopedics.com/portfolio/knee-replacement-surgery/healthbase_knee_implant_components_total_knee_replacement_tkr/
42. Kurtz, S. M., Ong, K. L., Lau, E., Widmer, M., Maravic, M., Gómez-Barrena, E., Röder, C. (2011, March 15). International survey of primary and revision total knee replacement. Retrieved May 21, 2020, from https://link.springer.com/article/10.1007/s00264-011-1235-5/tables/3
43. Laskin, R. S. (1991). The Surgical Technique of Total Knee Replacement. In Total Knee Replacement (1st ed., pp. 41–55). British Library. doi: 10.1007/978-1-4471-1825-1
44. Lippert, L. s. (2006). Articular System, In Clinical Kinesiology and Anatomy (4th ed., pp. 18–19). Philadelphia, PA: E.A Davis Company.
45. Lippert, L. S. (2006). Chapter 18- Knee. In Clinical Kinesiology and Anatomy (4th ed., pp. 251–255). Philadelphia, PA: E.A Davis Company.
46. Macgroarty, K. (2017). PDF. Brisbane.
47. Mansfield, P. J., & Neumann, D. A. (2019). Chapter 10: Structure and Function of the Knee. In Essentials of Kinesiology for the Physical Therapist Assistant (3rd ed., pp. 278–310). Elsevier. doi: https://doi.org/10.1016/B978-0-323-54498-6.00010-2
48. Muderis, M. A. (2016, January 14). History of Knee Arthroplasty. Retrieved May 21, 2020, from https://www.almuderis.com.au/knee-surgery/knee-arthroplasty/information/history-of-knee-arthroplasty
49. Muscolino, J. E. (2017). Tibiofemoral (Knee) Joint. In Kinesiology: The Skeletal System and Muscle Function (3rd ed., pp. 273–273). St.Louis, Missouri: Elsevier.
50. Myers, T. W. (2009). Chapter 3: The Superficial Back Line. In Anatomy Trains (2nd ed., pp. 72–73). London: Elsevier.
51. Myers, T. W. (2009). Chapter 4: The Superficial Front Line. In Anatomy Trains (2nd ed., pp. 94–95). London: Elsevier.
52. Neckel, N., Pelliccio, M., & Hidler, J. (2006). Quantification of functional weakness and abnormal synergy patterns in the lower limb of individuals with chronic stroke. Journal of NeuroEngineering and Rehabilitation Volume, 3. Retrieved from https://link.springer.com/article/10.1186/1743-0003-3-17
53. NHS. (2019, August 2). Overview -Knee replacement. Retrieved from https://www.nhs.uk/conditions/knee-replacement/
54. NHS. (2019, August 19). Symptoms -Osteoarthritis. Retrieved April 19, 2020, from https://www.nhs.uk/conditions/osteoarthritis/symptoms/
55. O'Leary, C. (2020, May 28). Femoral artery. Retrieved May 28, 2020, from https://www.kenhub.com/en/library/anatomy/femoral-artery
56. Oh, G., & Bell, D. J. (2019, December). Popliteal lymph nodes: Radiology Reference Article. Retrieved May 28, 2020, from https://radiopaedia.org/articles/popliteal-lymph-nodes

57. Page, P., Frank, C. C., & Lardner, R. (2010). Chain Reactions. In Assessment and Treatment of Muscle Imbalance: The Janda Approach (pp. 30–37). Human Kinetics.
58. Paul, J., & Ezerskiy, V. (2011). The Effect of Foot Orthotics on Arch Height: Prediction of Arch Height Correction in Flat-foot Children. In Biocybernetics and Biomedical Engineering (Vol. 31, pp. 51–62). Elsevier. doi: https://doi.org/10.1016/S0208-5216(11)70005-5
59. Perry, J. (1974). Kinesiology of Lower Extremity Bracing. Clinical Orthopaedics and Related Research, 102, 18–31. doi: 10.1097/00003086-197407000-00004
60. Pezzoti, C. (n.d.). ANATOMY LAB PRACTICAL at Broward Community College. Retrieved May 11, 2020, from https://www.studyblue.com/notes/note/n/anatomy-lab-practical/deck/1249836
61. Polley, J. (2017, June 14). Why a Knee Is Rarely a Knee. Retrieved May 21, 2020, from https://www.ptaglobal.com/blog/ptag-blog/why-a-knee-is-rarely-a-knee
62. Rafiqul Islam, M. (2019, October 29). Lower Limb: Bones, Muscles, Joints & Nerves "How To Relief. Retrieved May 28, 2020, from http://www.howtorelief.com/lower-limb-bones-muscles-joints-nerves/
63. Roth, J., Team, O., & Padgett, D. (2020, January 17). Hip Biomechanics. Retrieved May 116, 2020, from https://www.orthobullets.com/recon/9064/hip-biomechanics
64. Sass, P., & Hassan, G. (2003). Lower Extremity Abnormalities in Children. American Family Physician., 461–468. Retrieved from https://www.aafp.org/afp/2003/0801/p461.html
65. Sharma, L., Song, J., Dunlop, D., Felson, D., Lewis, C. E., Segal, N., Nevitt, M. (2010). Varus and valgus alignment and incident and progressive knee osteoarthritis. Annals of the Rheumatic Diseases, 69(11), 1940–1945. doi: 10.1136/ard.2010.129742
66. Singh, J. A. (2011). Epidemiology of Knee and Hip Arthroplasty: A Systematic Review§. The Open Orthopaedics Journal, 5(1), 80–85. doi: 10.2174/1874325001105010080
67. Soong, J., Silva, A., & Andrew, T. H. (2017). Disruption of quadriceps tendon after total knee arthroplasty: Case report of four cases. Journal of Orthopaedic Surgery, 25(2), 230949901771720. doi: 10.1177/2309499017717206
68. Suszynski, B. M. (2016, February 9). Understanding Primary and Secondary Osteoarthritis: Everyday Health. Retrieved May 21, 2020, from https://www.everydayhealth.com/osteoarthritis/understanding-primary-and-secondary-osteoarthritis/
69. Swank, A. M., Kachelman, J. B., Bibeau, W., Quesada, P. M., Nyland, J., Malkani, A., & Topp, R. V. (n.d.). Prehabilitation before Total Knee Arthroplasty Increases Strength and Function in Older Adults with Severe Osteoarthritis. The Journal of Strength and Conditioning Research, 25(2), 318–325. doi: 10.1519/JSC.0b013e318202e431
70. Tran, J., Peng, P. W. H., Gofeld, M., Chan, V., & Agur, A. M. R. (2019). Anatomical study of the innervation of posterior knee joint capsule: implication

for image-guided intervention. Regional Anesthesia & Pain Medicine, 44(2), 234–238. doi: 10.1136/rapm-2018-000015
71. Troup, C. (2018, May 16). Gonarthrosis: What is it? Causes, Symptoms, Diagnosis and Treatment. Retrieved May 21, 2020, from https://scopeheal.com/gonarthrosis/
72. Velayutham, S. (2014, November 10). Coxa Vara, Genu VArum & Valgum. Under Gradts. Retrieved May 20, 2020, from https://www.slideshare.net/drsarthy/coxa-vara-genu-varum-valgum-under-gradts
73. WebMD. (2019, April 22). What are the different types of knee replacement surgery? Retrieved from https://www.webmd.com/osteoarthritis/qa/what-are-the-different-types-of-knee-replacement-surgery
74. Wedro, B. (2019, September 26). How Do Dermatomes Work? Map, Myotomes vs. Dermatomes. Retrieved May 24, 2020, from https://www.emedicinehealth.com/dermatomes/article_em.htm
75. Wendy. (n.d.). Human Anatomy and Physiology Lab (BSB 141). Retrieved May 11, 2020, from https://courses.lumenlearning.com/ap1x94x1/chapter/the-lower-limbs/
76. Wilson, C. (2018, October 11). Knee Ligaments - Cruciates & Collaterals - Knee Pain Explained. Retrieved from https://www.knee-pain-explained.com/knee-ligaments.html
77. Xue, N., Doellinger, M., Fripp, J., Ho, C. P., Surowiec, R. K., & Schwarz, R. (2014). Automatic model-based semantic registration of multimodal MRI knee data. Journal of Magnetic Resonance Imaging, 41(3), 633–644. doi: 10.1002/jmri.24609
78. Zelman, D. (2018, May 5). Osteoarthritis: Symptoms, Causes, Diagnosis, Treatment. Retrieved May 19, 2020, from https://www.webmd.com/osteoarthritis/guide/osteoarthritis-basics

5. Supplements

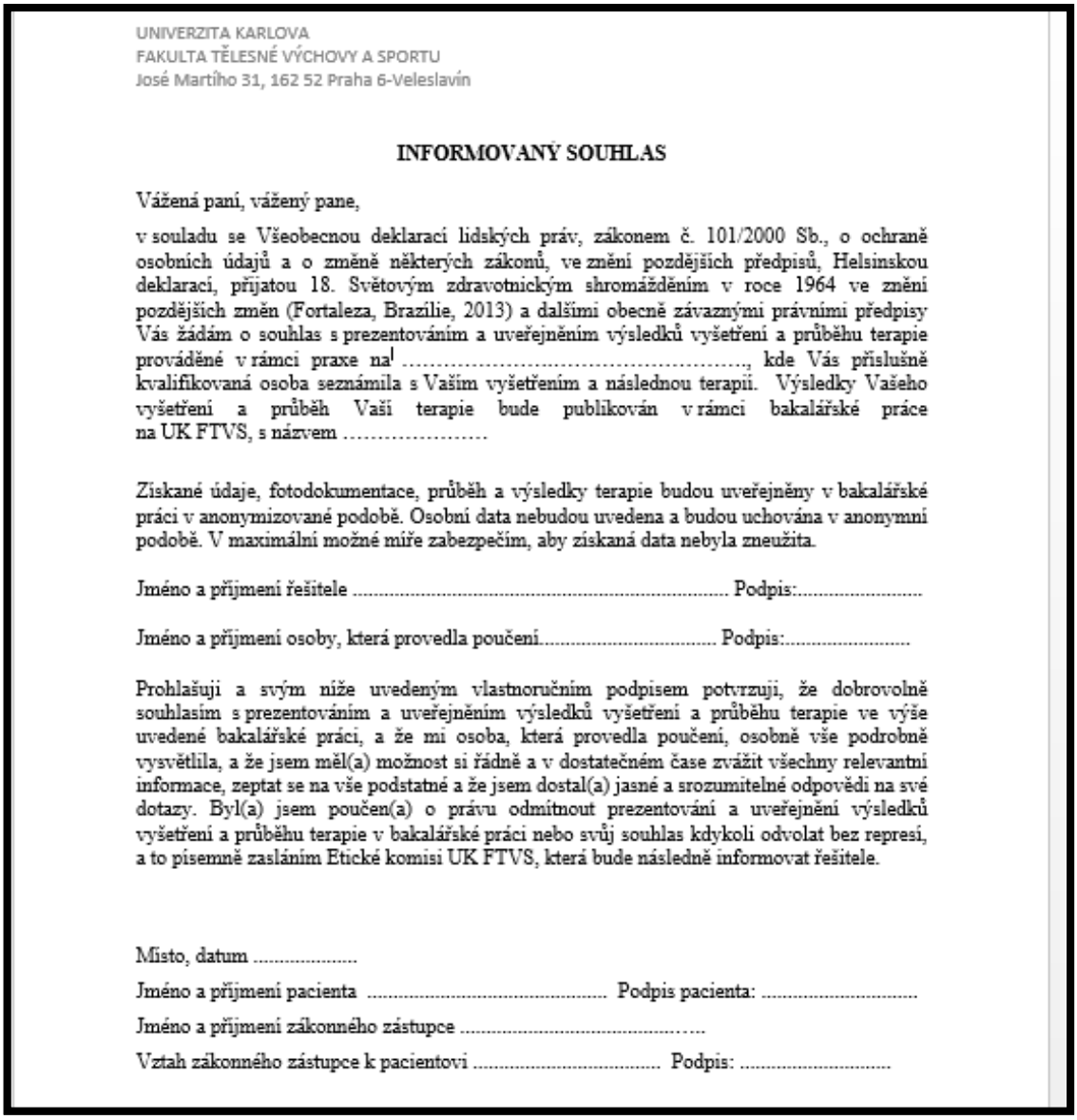
5.1 List of Images

5.2 List of tables

5.3 Abbreviations

ABD	Abduction
ADD	Addcution
ACL	Anterior cruciate ligament
DF	Dorsiflexion
EXT	Extension
ER	External rotation
FLX	Flexion
IR	Internal rotation
LE	Lower extremity
MT	Metatarsal
PCL	Posterior cruciate ligament
PF	Plantar flexion
ROM	Range of motion

5.4 Ethics



UNIVERZITA KARLOVA
FAKULTA TĚLESNÉ VÝCHOVY A SPORTU
José Martího 31, 162 52 Praha 6-Veleslavín

INFORMOVANÝ SOUHLAS

Vážená paní, vážený pane,

v souladu se Všeobecnou deklarací lidských práv, zákonem č. 101/2000 Sb., o ochraně osobních údajů a o změně některých zákonů, ve znění pozdějších předpisů, Helsinskou deklarací, přijatou 18. Světovým zdravotnickým shromážděním v roce 1964 ve znění pozdějších změn (Fortaleza, Brazílie, 2013) a dalšími obecně závaznými právními předpisy Vás žádám o souhlas s prezentováním a uveřejněním výsledků vyšetření a průběhu terapie prováděné v rámci praxe na[1] ……., kde Vás příslušně kvalifikovaná osoba seznámila s Vaším vyšetřením a následnou terapií. Výsledky Vašeho vyšetření a průběh Vaší terapie bude publikován v rámci bakalářské práce na UK FTVS, s názvem ……

Získané údaje, fotodokumentace, průběh a výsledky terapie budou uveřejněny v bakalářské práci v anonymizované podobě. Osobní data nebudou uvedena a budou uchována v anonymní podobě. V maximální možné míře zabezpečím, aby získaná data nebyla zneužita.

Jméno a příjmení řešitele ..... Podpis:.....

Jméno a příjmení osoby, která provedla poučení..... Podpis:.....

Prohlašuji a svým níže uvedeným vlastnoručním podpisem potvrzuji, že dobrovolně souhlasím s prezentováním a uveřejněním výsledků vyšetření a průběhu terapie ve výše uvedené bakalářské práci, a že mi osoba, která provedla poučení, osobně vše podrobně vysvětlila, a že jsem měl(a) možnost si řádně a v dostatečném čase zvážit všechny relevantní informace, zeptat se na vše podstatné a že jsem dostal(a) jasné a srozumitelné odpovědi na své dotazy. Byl(a) jsem poučen(a) o právu odmítnout prezentování a uveřejnění výsledků vyšetření a průběhu terapie v bakalářské práci nebo svůj souhlas kdykoli odvolat bez represí, a to písemně zasláním Etické komisi UK FTVS, která bude následně informovat řešitele.

Místo, datum .....

Jméno a příjmení pacienta ..... Podpis pacienta: .....

Jméno a příjmení zákonného zástupce .....

Vztah zákonného zástupce k pacientovi ..... Podpis: .....

CHARLES UNIVERSITY
FACULTY OF PHYSICAL EDUCATION AND SPORT
José Martího 31, 162 52 Prague 6-Veleslavín

Application for Approval by UK FTVS Ethics Committee

of a research project, thesis, dissertation or seminar work involving human subjects

The title of a project: Case Study of Physiotherapy Treatment of a Patient with the Diagnosis Total Knee Replacement

Project form: bachelor theis

Period of realization of the project: January 2020 - February 2020

Applicant: Belinda Hlomayi

Main researcher: Belinda Hlomayi

Workplace: Ústřední Vojenská Nemocnice – supervisor Martin Lassner

Supervisor (in case of student's work): doc. PaedDr. Dagmar Pavlů

Project description: The aim of this project is to rehabilitate a given patient. My patient is after a surgery of total knee replacement therefore the aim is to restore him to the furthest level of independent function possible in the given time. This is done by regaining mobility in the joint, which is a combination of: reduction of pain, reduction on inflammation, strengthening and stretching of muscle groups in relation to the knee. Also it is important for the patient to be independent; post-surgery, the patient isn't really mobile therefore educating the patient how to walk with crutches and also how to use them on the stairs.
Characteristic of the participants: one patient, born 1957, diagnosis is Total Knee Replacement due to Primary Gonarthrosis (bilateral).
Ensuring safety within the research: non-invasive methods are used. To minimise risk my supervisor is present throughout the treatment. Risks of therapy and methods will not be higher than the commonly anticipated risks for this type of therapy.
Ethical aspects of the research: the participant is a non-vulnerable adult.
The collected data will be anonymized within one week after the end of working with the patient. I understand that anonymization means that the text does not use any item of information or combination of items that could lead to the identification of a person. I will be careful not to enable recognition of a person in the text of the thesis, especially within the anamnesis. After the text has been anonymized, any personal data still kept elsewhere will be deleted.
Photographs of the participant will be anonymized within one week after being taken by blurring the face, parts of the body or any characteristics that could lead to identification of the person. After anonymization any non-anonymized photographs will be deleted.
All collected data will be safely stored on a PC safeguarded by a keyword in a locked room, any data in paper form will be kept safely under lock and key in a locked room. The data will be processed, safely retained and published in an anonymous way in the bachelor thesis.
I shall insure that this data is strictly for the thesis and shall not be used or misused outside this work.
Informed Consent: attached

It is a duty of **all participants of the research team** to protect life, health, dignity, integrity, the right to self-determination, privacy and protection of the personal data of all research subjects, and to undertake all possible precautions. Responsibility for the protection of all research subjects lies on the researcher(s) and not on the research subjects themselves, even if they gave their consent to participation in the research. All participants of the research team must take into consideration ethical, legal and regulative norms and standards of research involving human subjects applicable not only in the Czech Republic but also internationally.
I confirm that this project description corresponds to the plan of the project and in case of any change, especially of the methods used in the project, I will inform the UK FTVS Ethics Committee, which may require a re-submission of the application form.
In Prague, 05/02.2020 Applicant's signature: Belinda

Approval of UK FTVS Ethics Committee

The Committee: Chair: doc. PhDr. Irena Parry Martínková, Ph.D.
Members: prof. PhDr. Pavel Slepička, DrSc.
prof. MUDr. Jan Heller, CSc.
Mgr. Pavel Hráský, Ph.D.
Mgr. Eva Prokešová, Ph.D.
Mgr. Tomáš Ruda, Ph.D.
MUDr. Simona Majorová

The research project was approved by UK FTVS Ethics Committee under the registration number: 067/2020
Date of approval: 10.1.2020

UK FTVS Ethics Committee reviewed the submitted research project and **found no contradictions** with valid principles, regulations and international guidelines for carrying out research involving human subjects.

The applicant has met the necessary requirements for receiving approval of UK FTVS Ethics Committee.

UNIVERZITA KARLOVA
Fakulta tělesné výchovy a sportu
José Martího 31, 162 52, Praha 6
– 20 –

Stamp of UK FTVS

Signature of the Chair of
UK FTVS Ethics Committee