Diplomarbeit

Analysis of gait pattern after Roux-Elmslie-Trillat treatment in patients after recurrent patella dislocation

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1. Zusammenfassung

Zweck

Material und Methoden

Ergebnisse
13 Patienten (14 Kniegelenke) wurden ausgewertet. 8 Frauen und 7 Männer, das mittlere Alter betrug 30.2 Jahre (sD= 7.5; Bereich: 21–52). Die mittlere Nachbeobachtungszeit betrug 188 Wochen (sD= 80.3; Bereich: 70–320). Der mittlere IKDC-Score betrug 77.4 Punkte (sD= 14.5; Bereich: 47.1), mittlerer Lysholm 87.5 Punkte (sD= 10.4; Bereich: 69-100), mittlerer Kujala-Score 87.6 (sD= 8.8; Bereich: 70–98). Es kam zu einer Reluxation. Es gibt keinen signifikanten Unterschied in der Gehgeschwindigkeit zwischen der Studiengruppe und der Kontrollgruppe. Es besteht kein signifikanter Unterschied in der maximalen Knieflexion (während des Gehens) zwischen Patienten und Kontrollgruppe. Prädisponierende Faktoren wurden bei den meisten Patienten operativ verbessert.

Conclusio
2. Abstract

Purpose
Recent attention has been focused on the long-term results after Roux-Elmslie-Trillat procedure. However, little is known about the gait pattern after the surgery. Additionally, patella dislocation is a common injury seen in the casualty department mostly in young athletes. Proper treatment will prevent sequelae and symptoms and thus a limitation in daily life.

Material and Methods
Patients, who were treated with Roux-Elmslie at the University Hospital of Accident Surgery at the Vienna General Hospital in the period from 2010 to 2016 due to a chronic patellar luxation, were included. Clinical assessments and questionnaires and knee scores (IKDC, Kujala, Lysholm, PIS) were used to measure clinical symptoms, subjective perception, pain and activities of daily life. Radiological imaging was used to show up any malformations or other predisposing factors, such as tuberositas tibiae-trochlea groove (TT-TG) distance or q-Angle. Moreover, a 3D gait analysis was performed to analyse the gait pattern of the patients (spatial-temporal parameters as well as kinematic and kinetic data).

Results
13 patients (14 knees) were evaluated. 8 were women and 7 men, median age was 30.2 years ($s_D = 7.5$; range: 21–52). The mean follow-up period was 188 weeks ($s_D = 80.3$; range: 70–320). The mean IKDC score was 77.4 points ($s_D = 14.5$; range: 47.1), mean Lysholm 87.5 points ($s_D = 10.4$; range: 69-100), mean Kujala score 87.6 ($s_D = 8.8$; range: 70–98). One re-dislocation was recorded. There is no significant difference in walking speed between study group and control group. There is no significant difference in maximum knee flexion (during a walk) between patients and control group. Predisposing factors were improved by surgery in most patients.

Conclusion
Based on the results of the present study, the Roux-Elmslie method can be described as a sufficient technique. It is a good treatment option for recurrent patellar dislocation, if the indications are given. Patients, who were treated with this technique, showed approximately the same physiological readings and data as the healthy control group at the time of follow-up.

In future a long-term prospective study should be planned, where patients are evaluated before and after surgery and physical activity is measured too. There should be not only one follow up check, but rather more follow up examinations after certain common periods for each patient to show up differences during the years after surgery.
3. Introduction
The incidence of a patellofemoral instability is 7/100,000 patients per year. Around 11% of the musculoskeletal symptoms are instabilities of the patellofemoral joint.\(^1\) These instabilities occur due to several clinical and radiological factors, such as ligamentous laxity, increased quadriceps angle (Q-angle), femoral anteversion, trochlear dysplasia, quadriceps dysplasia, excessive tibial tubercle-trochlear groove distance (TT-TG), excessive lateral patellar tilt, and patella alta.

If patients experience patella dislocation for the first time, a conservative treatment can decrease the risk of continuous luxation. More than 50% of treated patients will not experience a second dislocation, but their risk of subsequent dislocation is still increased.

If all conservative treatments fail and recurrent patella luxation is shown by the patient, the next step is surgery to reconstitute normal patellofemoral kinematics. There are different surgical techniques, which have different indications. Each patient has to be evaluated in order to address the instability properly. In some cases it is not easy to decide the most appropriate surgical technique.\(^2\)
3.1 Patellofemoral instability and patella dislocation

The term *patellofemoral malalignment* describes a variety of abnormal knee conditions, like acute or recurrent dislocation to abnormal gliding of the patella. Acute instability is commonly associated with primary traumatic incident and a lateral dislocation of the patella. However, chronic instability describes recurrent dislocations. A medial dislocation is unusual and mostly iatrogenic, which means “caused by a doctor”.\(^3,^4\)

Mainly adolescents and young adults are affected, while doing sports or daily activities. Frequently shown symptoms are acute knee pain and hemarthrosis, spontaneous remission is found in many cases. About 50% of the patients are clinically unsuspicious, MRI leads to the diagnosis.\(^5,^6\)

The therapy options are surgical and non-surgical techniques, the main goal is to correct the underlying malalignment. Conservative treatment is only recommended for the first time dislocation and includes a combination of early range of motion (ROM) and quadriceps strengthening with or without bracing or taping, which means immobilization in extension for three to six weeks. To regulate inflammation use is made of relative rest, ice, compression and elevation (RICE principle) in acute management.\(^2,^6\)

There are different procedures to select in each case as surgical options:

- *proximal soft tissues procedures*, such as lateral release, vastus medialis obliquus (VMO) plasty and medial patellofemoral ligament (MPFL) reconstruction
- or *distal bony realignment procedures*, including tibial tuberosity transfer and trochleoplasty

If there is a significant evidence of patellar maltracking, intensive physiotherapy is advised in post-treatment. A distal realignment procedure is only recommended for patients with recurrent traumatic patellar dislocations.

In some cases patella dislocation is associated damage to the anterior cruciate ligament, MRI confirms injuries.\(^5\)

Dislocations due to trauma are very uncommon in a patient without predisposing factors. Of the above-mentioned risk factors, the following are the most common: trochlea dysplasia, patella alta and lateralization of the tibial tuberosity.

- *trochlear dysplasia*: Usually, the trochlea is concave and has facets medially and laterally, which communicate with the medial and lateral facets of the articular surface of the patella. Anatomic varieties modify the trochlear surface and lead to loss of normal patellar tracking. 85% of patients with dislocation have an evidence for trochlea dysplasia. These include lateral trochlear inclination, trochlear facet
asymmetry, trochlear depth and trochlear morphology according to Dejour. To quantify trochlear dysplasia, techniques with MRI or x-ray have been standardized.

- lateralization of the patella: If there is a bigger distance than 6mm between the most lateral point of patella and line paralleling the lateral surface of the femur in MRI, it has a sensitivity of 75% and specificity of 83% for trochlea dysplasia. Another method, starting with a line tangent to the posterior part of femoral condyles, measures the distance from a second perpendicular line, which rises anteriorly through the medial margin of trochlea, to the medial edge of patella. A distance greater than 2mm is considered as abnormal.

- patella alta: This predisposing factor is shown in patients with a too long patellar tendon, which allows the patella to be situated too high above the trochlear fossa. The patella is not able to communicate with the trochlear groove until the knee is flexed more than 30°. As a result, the patellar contact surface is reduced and the stability lessens in initial flexion. To asses patella alta, one uses the Insall-Salvati ratio in radiological imaging with full extension of the knee. The length of the patellar tendon (from the apex to its attachment, a) is divided by the longest superio-inferior distance of patella (b). A ratio of more than 1.3 is an indication for patella alta. (Fig.1)

![Insall-Salvati-ratio.](image)

- lateralization of the tibial tuberosity: With lateral displacement of the tuberositas tibiae, the patella is dragged laterally while flexion. The tibial tuberosity-trochlear groove (TT-TG) distance measures the pull from the patella.
3.2 Purpose
Recent attention has been focused on the long-term results after Roux-Elmslie-Trillat procedure. However little is known about the gait pattern after the surgery. Additionally, patella dislocation is a common injury seen in the trauma department in mostly young athletes.

Therefore, the purpose of the present clinical trial was to investigate the clinical outcome, the gait pattern and the morphological changes after a distal realignment via Roux-Elmslie-Trillat procedure. Subjective evaluation of the patient, clinical and radiological assessment and special examinations in the gait laboratory provided the results.

The main question is whether there are re-dislocations or other symptoms or complications after surgery after Roux-Elmslie-Trillat.
4. The Human Knee

4.1 Anatomy

The knee is the largest joint in the human body. It consists of two joints between femur, tibia and patella: the tibiofemoral joint and the patellofemoral joint.

The joint surfaces of femur and tibia, which are covered with cartilage, are called the medial and lateral condyle. Additionally there is another joint surface on femur (patellar surface), which is connected with the cartilage-covered articular surface of the patella. (Fig. 2,3,4)\(^7\)

4.1.1 Articular bodies and surfaces

The femur has two main articular bodies, the lateral and medial condyles. The lateral condyle is broader in front than at the back, whereas the width of the medial condyle is steadier. Both diverge minor a distal and posterior direction. The condyles' curvature decrease backwards and so does its radius in sagittal axis. Therefore, the involute midpoints, produced by the shrinking radius, are positioned on a spiral. As a result, the sliding and rolling movement in the flexing knee is allowed by the outcoming series of transverse axes. Additionally, a sufficient laxity of the collateral ligaments has to be ensured to approbate the rotation related to the curving of the medial condyle about a vertical axis.

The articular bodies of the tibia are a pair of condyle as well. They are detached by the intercondylar eminence, which consists of a lateral and a medial tubercle.

The kneecap operates as an articular body too. Its surface in the back is the so-called “trochlea of the knee” and is involved in an anterior thin-gauged part of the joint capsule. On the posterior side of the patella there is a lateral and a medial articular surface. Both of them communicate with the patellar surface of the femur and consequently connect the medial and lateral condyles of the femur anteriorly of the bone's lower end.\(^7,8,9\)

Articular surfaces of femur:

![Articular surfaces of femur](image)

Fig. 2: Henry Gray (1825–1861). Anatomy of the Human Body. 1918. FIG. 246. Lower extremity of right femur viewed from below.
Articular surfaces of tibia:

Fig. 3: Henry Gray (1825–1861). Anatomy of the Human Body. 1918. FIG 257. Upper surface of right tibia.

Articular surfaces of patella:

Fig. 4: Henry Gray (1825–1861). Anatomy of the Human Body. 1918. FIG. 256 Right patella. Posterior surface.

4.2 Menisci

The menisci are two semilunar fibrocartilages in the knee-joint. They cover the surfaces of the head of the tibia for articulation with the condyles of the femur. The outer border of each meniscus is thick, convex and fixed to the inside of the articular capsule, while the proximal border is thin, concave and unattached. The superior surfaces are concave and in contact with the condyles of the femur, the inferior surfaces are flat and cover the head of the tibia. Their surfaces are equally sleek and vested with synovial membrane. Both of the two menisci cover about the peripheral two-thirds of the matching articular surface of the tibia. Their functions are the enlargement of the contact surface between tibia and femur and the compensation of incongruences between the condyles. In addition, they ensure a better distribution of the synovial fluid on the articular surfaces.7,8,9
4.2.1 Medial meniscus

The medial meniscus, also *internal semilunar fibrocartilage* or *inner meniscus*, is located medially between the articular surfaces of the femur and the tibia. It is formed semi-circular and can be divided into three sections: The cornu anterius, which is the anterior horn; the pars intermedia, which is central part of the meniscus and the cornu posterius, the posterior horn.

The back is broader than the anterior and is attached to the posterior intercondyloid fossa of the tibia, near the posterior cruciate ligament. The front side is slim and pointed and is fixed to the anterior intercondyloid fossa of the tibia, in front of the anterior cruciate ligament.

Contrary to the lateral meniscus, the inner meniscus is firmly connected to the medial surface of the joint capsule and the medial collateral ligament of the knee joint. The cornu anterius is affixed by the anterior meniscotibial ligament in the intercondylar fossa anterior to the tibia; while the cornu posterius is fasten by the posterior meniscotibial ligament in the posterior intercondylar fossa.

External rotation stresses the medial meniscus, but in internal rotation it is relieved.7,8

4.2.2 Lateral meniscus

The lateral meniscus, also *external semilunar fibrocartilage* or *outer meniscus* is placed laterally between the articular surfaces of the femur and the tibia. It is shaped like a sickle or a three-quarter circle and covers a larger part of the articular surface than the inner one. It can also be separated into the three sections like the medial meniscus: the cornu anterius, the pars intermedia and the cornu posterius. There is a groove for the tendon of the popliteus muscle on the lateral side. The tendon separates the meniscus from the fibular collateral ligament.

The outer meniscus is only slightly fused with the ligamentous structures of the joint capsule and thus somewhat more freely movable. Its anterior horn is appended to the front of the eminentia intercondylaris of the tibia and also behind the anterior cruciate ligament, with which it fusions. The posterior horn is fixated to the back of the intercondyloid eminence and to the front of the posterior end of the medial meniscus.

The anterior bonding is warped on itself. As a result, the free margin looks backward and upward and the anterior end lies on a slanting board of lateral process of the intercondyloid eminence.

Just before its posterior attachment, the outer meniscus delivers a thick fascicule known as the ligament of Wrisberg, or *posterior meniscofemoral ligament*. The ligament of Humphrey, or *anterior meniscofemoral ligament*, is also located at the lateral meniscus, but less common.
Occasionally there is another small fibre-bundle from the outer meniscus, which merges into the lateral part of the anterior cruciate ligament. Despite that, the lateral meniscus forms the transverse ligament by sending off a bundle from its anterior convex margin. The outer meniscus is stressed in an internal rotation, but relieved in an external rotation.

4.3 Ligaments

The primary function of the ligaments is to stabilize the knee by limiting movements and protect the articular capsule along with the menisci and certain bursae. They are surrounding the knee joint and keep the bones connected to each other.

4.3.1 Intracapsular

The cruciate ligaments are two out of the four most important ligaments of the knee joint and stabilize the knee. There are two different cruciate ligaments, the anterior cruciate ligament (ACL) and the posterior cruciate ligament (PCL). The ACL has two bundles, a small anteromedial and a large posterolateral bundle, which names are according to the insertion of the bundles into the tibial plateau. It starts at the lateral condyle of the femur and attaches at the intercondyloid eminence of the tibia. (Fig. 6)

The PCL is longer and stronger than the ACL. It stretches from the lateral aspect of medial femoral condyle to the posterior intercondyloid fossa of the tibia, while crossing the ACL. (Fig. 6)
The anterior meniscofemoral ligament, also known as ligament of Humphrey, is fastened from the posterior horn of lateral meniscus to lateral surface of medial condyle of the femur, while crossing the PCL superiorly. (Fig. 6)

The posterior meniscofemoral ligament, also known as ligament of Wrisberg, also originates at the posterior horn of lateral meniscus, crosses PCL superiorly and inserts at the medial condyle of femur. (Fig. 6, 7)

The transverse or (anterior) meniscomeniscal ligament is very variable in thickness and shaping. It is one out of four described meniscomeniscal ligaments and connects the anterior horn of the lateral meniscus and the medial meniscus. (Fig. 7)\(^7,8,10\)
The meniscotibial (or coronary) ligaments are part of the joint capsule. They arise at the inferior edges of each meniscus and are attached to the head of the tibia.  

Fig. 7: Henry Gray (1825–1861). Anatomy of the Human Body. 1918. FIG. 349. Head of right tibia seen from above, showing menisci and attachments of ligaments.
4.3.2. Extracapsular

The patellar ligament, also known as the patellar tendon, continues with the distal part of the tendon of the quadriceps femoris. It is a very strong ligament, which is relevant for the typically mechanical leverage of the patella, and connects the patella and the tuberosity of the tibia. (Fig. 8,9)

Laterally and medially next to the patella, there is the lateral and medial retinaculum, which attaches fibres from vastus lateralis or vastus medialis to the tibia. (Fig. 8)\textsuperscript{7,8,10}

\textbf{Fig. 8}: Henry Gray (1825–1861). Anatomy of the Human Body. 1918. FIG. 345. Right knee-joint. Anterior view.
The collateral ligaments are the other two most important ligaments of the knee joint. The medial or tibial collateral ligament (MCL, TCL) is on the inner side, while the lateral or fibular collateral ligament (LCL, FCL) is on the outer side. Their primary function is to resist the valgus (MCL) or varus (LCL) forces on the knee. The MCL stretches from the medial epicondyle of the femur to the medial condyle of tibia and the LCL from the lateral epicondyle of the femur to the head of fibula. Additionally, the LCL belongs to the posterolateral corner of the knee. (Fig. 8,10)

Anterior to the LCL, there is the anterolateral ligament (ALL). It was recently redescribed from Claes et al in 2013 and connects the lateral epicondyle of the femur and the anterolateral aspect of the proximal tibia.\(^{11}\)

The oblique popliteal ligament arises at lateral epicondyle of the femur and the lateral condyle of the femur and attaches to the medial condyle of the tibia. It is a short and broad ligament, which forms the ground of the popliteal fossa. Besides, the oblique popliteal ligament incorporates parts of the tendon of semimembranosus and is in close anatomical relationship with the popliteal artery. (Fig 9,10)\(^{7,8,10}\)
The arcuate popliteal ligament, which is Y-shaped, originates at the posterior part of the head of the fibula and inserts on two locations: The medial one blend with the oblique popliteal ligament, while covering some parts of the popliteus muscle and the lateral one to the Lateral epicondyle of the femur, which merges with the lateral head of the gastrocnemius muscle.\textsuperscript{7,8,10}

### 4.4 Articular capsule

The Capsula articularis is a thin, but very strong, fibrous membrane, which surrounds all articular surfaces of the knee joint including the patella. It is strengthened by the fascia lata, the surrounding tendons and ligaments and consists of two layers: The membrana fibrosa, which is made out of fibers and stabilizes the capsule, and the membrana synovialis lines the knee joint from inside with synovial fluid. Underneath the tendon of the Quadriceps femoris there is only the synovial membrane.

The joint capsule is indivisible connected with the ligaments of the knee-joint. The posterior cruciate ligament lies outside the joint capsule, which makes the joint space horseshoe-shaped in horizontal section. The most stable part is on the dorsal side of the knee and the ventral side is firmly connected to the ligamentum patellae. Lateral, the point of exit of the popliteus muscle is found. The capsula attaches to the edges of the tibial condyles distally and fuses with the menisci there.\textsuperscript{7,8}
Moreover, there is a fat substance, called the *corpus adiposum infrapatellare*, the *Hoffa fat pad* or *intrapatellar fat pad*, which is located between the membrana fibrosa and the membrana synovialis. It is used for cushioning under the synovium.

Furthermore, the joint cavity is traversed by mucosal folds (plicae synoviales), which zone the various specific regions. These are the plica suprapatellaris (SPP), the plica mediopatellaris (MPP) and the plica infrapatellaris (IPP). The suprapatellar plica separates the suprapatellar recess, while the medial patellar plica is situated next to the patellas medial facet and extends vertically along to the articular capsule. The infrapatellar plica runs from the intercondylar notch to the infrapatellar fat pad and is located in front of the anterior cruciate ligament.\(^7,8\)

### 4.4.1 Bursae

A bursa is a thin-gauged fluid sac or synovial pocket that can enlarge in inflammation. The knee joint is surrounded by numerous bursae, some of them communicate with the joint cavity. They can be grouped after location:

**Frontal bursa**

- The bursa suprapatellaris, also *suprapatellar recess*, is located above the patella and reaches from the anterior surface of the distal part of the femur to the deep surface of the quadriceps femoris. It enables the movement of the quadriceps tendon over the lower end of the femur and communicates with the joint cavity.
- The bursa praepatellaris is situated anterior to the knee joint between the patella and the skin and has no connection to the joint cavity. It makes the motion of the skin
above the underlying patella possible and results in the common "housemaid's knee" when inflamed, which happens to people who frequently kneel.

- The bursa infrapatellaris profunda, or *deep infrapatellar bursa*, lies below the patella, between the patellar ligament and the proximal end of the tibia, which allows the gliding of the patellar ligament over the tibia.
- The bursa infrapatellaris subcutanea, or *superficial infrapatellar bursa*, is localized between the patellar ligament and the skin.
- The bursa praetibialis is placed between the tibial tuberosity and the skin and enables the moving of the skin above the tibial tuberosity.

**Lateral bursa**

- The bursa subtendinea musculi gastrocnemii lateralis runs between the origin of the lateral head of the gastrocnemius muscle and the joint capsule, behind the lateral condyle of the femur and sometimes communicates with the joint.
- The bursa subtendinea musculi bicipitis femoris, also known as *fibular bursa*, reaches from the lateral (fibular) collateral ligament to the tendon of the biceps femoris.
- The bursa fibulopoplitealis extends between the fibular collateral ligament and the tendon of the popliteus.
- The bursa musculi poplitei, also called the *subpopliteal recess*, is located between the tendon of the popliteus and the lateral condyle of the femur and stands in relation to the joint cavity.

**Medial bursa**

- The bursa subtendinea musculi gastrocnemii medialis is situated between the origin of the medial head of the musculus gastrocnemius and the medial condyle of the femur. It is connected with the knee-joint.
- The bursa anserine lies between the pes anserinus superficialis, which is a fusion of the tendons of the sartorius, semitendinosus and gracilis muscles on the medial condyle of the tibiae, and the ligamentum collaterale mediale (tibiale). It ensures the mobility of the tendons of the sartorius, semitendinosus and gracilis stands in relation to the ligamentum collateral tibiale.
- The bursa subtendinea musculi semimembranosi, also the *Brodie's Bursa*, is localized between the medial collateral ligament and the tendon of the semimembranosus. It communicates with the joint cavity.
There is another bursa between the tendon of the semimembranosus and the head of the tibia and sometimes there is one between the tendons of the semimembranosus and semitendinosus muscle.\textsuperscript{7,8,10}

**Fig. 12:** Bursae of the knee. (https://cdn.shopify.com/s/files/1/0763/4541/files/Bursitis_Knee_Diagram_3cb98a0e-75ec-484b-b42d-65bd45640d72.jpg?v=1513149748)

**Fig. 13:** Bursae of the knee. (https://www.healthclues.net/blog/wp-content/uploads/2016/06/knee-bursitis-730x350.png)

### 4.5 Blood supply

The blood supply of the knee joint is guaranteed by multitudes arteries, which form many anastomoses among themselves. This dense collateral network is called “\textit{patellar network}” or “\textit{rete articulare genus}” and differentiable into a superficial and a deep plexus.

The superficial plexus is located between the fascia and skin around the patella, while building three well-defined arches. One is in the loose connective tissue over the Quadriceps femoris, above the upper margin of the patella. The other two are situated below the patella and in the fat tissue behind the ligamentum patellae. The deep plexus forms a dense network of vessels, which is placed on the distal end of the femur and proximal end of the tibia around their articular surfaces. It sends numerous offsets into the interior of the joint. Both are located on the front side of the knee and primary built by the femoral artery, the popliteal artery and
their main branches. Only the medial genicular artery pierces the knee-joint. Although the patellar network has numerous inflows, its blood-flow is not sufficient to compensate for a closure of the popliteal artery and to ensure adequate blood supply to the lower leg. The following vessels assist in the formation of the patellar plexus:

- **Arteria genus descendens**: It is also known as the highest genicular artery and a branch of the femoral artery. The descending genicular artery arises from the femoral artery and ramifies in two branches: the saphenous branch of descending genicular artery, which accompanies the saphenous nerve, and the articular branches of descending genicular artery.

- **Arteria genus media**: The middle genicular artery is a small branch of the popliteal artery and originates on the back of the knee-joint. It penetrates the oblique popliteal ligament and supplies the synovial membrane and the interior structures (e.g. the menisci or ligaments) of the articulation.

- **Arteria superior lateralis genus**: It also arises from the popliteal artery and treks under the biceps femoris tendon to the lateral condyle of the femur, where the vessel separates in a superficial and a deep division (ramus). The ramus superficialis supplies the vastus lateralis and anastomoses with the descending branch of the lateral femoral circumflexa and the lateral genicular arteries in rete articulare genus. The ramus profundus anastomoses with Arteria genus descendens and supplies the distal femur and the proximal parts of the knee-joint.

- **Arteria superior medialis genus**: The medial superior genicular artery is a mostly bland branch of arteria poplitea, which wraps around femur above the epicondyles medialis femoris, while crossing the adductor magnus tendon. It runs in front of the semimembranosus and semitendinosus muscles and above the medial head of the gastrocnemius muscle and splits in two separate vessels. One supplies the musculus vastus medialis and anastomoses with Arteria genus descendens and Arteria inferior medialis genus. The other one arborizes on the surface of the femur and supplies the knee-joint, while anastomosing with the Arteria superior lateralis genus. Both rami are part of the rete articulare genus. The medial superior genicular artery is commonly of smaller size, which is in association with a bigger size of the highest genicular artery.

- **Arteria inferior lateralis genus**: This branch of the popliteal artery is on the outer side of the knee. It arises laterally from the head of the fibula, while crossing the lateral head of the gastrocnemius muscle, the fibular collateral ligament and the tendon of the biceps femoris muscle, and attaches at the front of the knee-joint. It divides into
branches, which merges with the inferior medial genicular and superior lateral genicular arteries and with the anterior recurrent tibial artery. It is also a building part of the *rete articulare genus*.

- **Arteria inferior medialis genus**: The inferior medial genicular artery, which arises from the popliteal artery as well, is located on the inside of the knee. It runs along the musculus popliteus, where it provides several rami musculares. Afterwards it wraps around the medial condyle of the tibia, beneath the tibia collateral ligament and ascends at the anterior border to the front and medial side of the knee. In its progression it supplies the proximal part of the tibia and partially the knee-joint. It ends by dividing into branches, which anastomose with lateral inferior and medial superior genicular arteries, while building the *rete articulare genus*.

- **Arteria recurrens tibialis anterior**: The anterior tibial recurrent artery is a branch given off from the anterior tibial artery, which is one of the two terminal branches of the popliteal artery. It is a small artery and flows, after passing the interosseous space, into the direction of the tibialis anterior muscle. The vessel ramifies on the front and the sides of the knee-joint and supports the patellar plexus by merging with the genicular branches of the popliteal and descending genicular artery.

- **Arteria recurrens tibialis posterior**: The posterior tibial recurrent artery is a branch of the anterior tibial artery. It arises before passing the gap between the superior tibio-fibular joint and upper margin of the interosseous membrane. The artery rises in front of the popliteus muscle and supplies it. Furthermore it anastomoses with the inferior medial genicular and inferior lateral genicular arteries, which offsets supply the tibiofibular joint.

- **Arteria circumflexa femoris lateralis (Ramus descendens)**: The lateral femoral circumflex artery originates from the profunda femoris artery or may occasionally arise directly from the femoral artery and runs between the divisions of femoral nerve and behind the sartorius and rectus femoris nerve. It ramifies into three branches, the ascending, the transverse and the descending branch. The descending branch of lateral circumflex femoral artery descends behind the musculus rectus femoris, upon the musculus vastus lateralis, while supplying it. One long off-set runs down to the knee in the muscle and merges with superior lateral genicular artery. In its course the femoral nerve comes along with the artery to the vastus lateralis muscle.
Arteria tibialis posterior (Ramus circumflexus fibularis): The posterior tibial artery is the other one of the two terminal branches of the popliteal artery. It runs at the base of the popliteus muscle, accompanied by the tibial nerve and its veins, to the lower flexor box of the lower leg. The artery arise a branch, called the fibular circumflex artery, and a calcaneal branch. On the sole of the foot the vessel splits in the Arteria plantaris medialis and the Arteria plantaris lateralis. Arteria circumflexa fibularis wraps laterally around the collum fibulae and pierces the musculus soleus. It anastomoses with the inferior lateral genicular artery, the middle genicular artery and the anterior tibial recurrent artery in the rete articular genus.7,10

4.6 Patellar plexus

The plexus patellae is formed of fine nerves and lies in the subcutaneous tissue above the patella. It runs from the patella to the ligamentum patellae and to the proximal end of the tibia. This neuroplexus is formed by the Ramus infrapatellaris of the saphenous nerve, as well as by branches of the femoral nerve and branches of the lateral cutaneous nerve.

- **Nervus saphenus (Ramus infrapatellaris):** The saphenous nerve is the largest cutaneous and terminal branch of the femoral nerve. It arises on the thigh, before passing through the Lacuna musculorum and is a strictly sensory nerve. The nerve runs with the femoral artery and vein through the adductor canal to the inner side of the
thigh and ascends there to the surface, where it supplies the inner side of thigh and lower leg. Finally, it descends with the saphenous vein on the medial side of the lower leg, where it releases numerous rami cutanei cruris mediales. It provides the ramus infrapatellaris near the lower pole of the kneecap. 

The infrapatellar branch of saphenous nerve is situated distal to the patella and about the middle of the thigh. It sensorial innervates the skin in front of and below the kneecap and forms the patellar plexus with branches of the femoral nerve and of the lateral cutaneous nerve of femoral nerve above the knee. (Fig. 16)

Fig. 16: Henry Gray (1825–1861). Anatomy of the Human Body. 1918. FIG. 835. Deep nerves of the front of the leg.

- Nervus femoralis (Rami cutanei anteriores nervi femoralis): The femoral nerve originates from the lumbar plexus (spinal segments L1-L4) and has motor and sensory qualities. It runs from the lateral margin of the psoas major muscle, below the iliac fascia and between the psoas and iliac muscles, through the lacuna musculorum to the
thigh. The nervus femoralis supplies the musculus iliopsoas and musculus pectineus with rami musculares and gives off rami cutanei anteriores for the front of the thigh, besides to the saphenous nerve. The anterior cutaneous branches can be differentiated in the intermediate and medial cutaneous nerve.

→ The intermediate cutaneous nerve or middle cutaneous nerve runs below the ligamentum inguinale, while piercing the fascia lata and sartorius muscle, down on the ventral side to the knee-joint. It splits in two branches, the medial and lateral, which supply the skin on forefront of the knee. They connect with the anterior division of lateral cutaneous nerve, the anterior division of medial cutaneous nerve and the infrapatellar branch of the saphenous to the patellar plexus. In the upper thigh the lateral branch is in relation to the lumboinguinal branch of the genitofemoral nerve.

→ The medial cutaneous nerve or internal cutaneous nerve lies obliquely on the upper part of the sheath of the femoral artery and divides there into two branches, an anterior and a posterior. The anterior one passes over the sartorius muscle downwards, pierces the fascia lata and splits into two divisions. One supplies the skin on the medial side of the knee; the other one crosses to the lateral side of the patella and connects with ramus infrapatellaris of nervus saphenous. The posterior branch runs down on the medial border of the sartorius to the knee. There it penetrates the fascia lata, communicates with the saphenous nerve and sends out numerous cutaneous branches, while continuing descending. It supplies the medial side of the leg and forms the subsartorial plexus with branches of the saphenous and obturator nerves.

- Nervus cutaneus femoris lateralis (Rami anterior): The lateral cutaneous nerve of the thigh, or lateral femoral cutaneous nerve, is given off by the plexus lumbalis (L2-L3). The nerve starts at the psoas major muscle and moves anteriorly below the fascia of the iliac musculature to the anterior superior iliac spine. Afterwards it passes through the lacuna musculorum under the fascia lata to the lateral thigh, where it ramifies into an anterior and a posterior branch. The posterior branch perforates the fascia lata and divides branches, which turn backwards to the lateral and posterior surfaces of the thigh and supply the skin from the height of the trochanter major to the middle of the thigh.

→ The anterior branch runs superficially below the inguinal ligament and splits into filaments, which are allocated to the skin of the anterior and lateral parts of the thigh and the knee. The endings commonly communicate with the rami cutanei anteriores of the nervus femoralis, and with ramus infrapatellaris of nervus saphenus.\textsuperscript{7,10}
Fig. 17: Henry Gray (1825–1861). Anatomy of the Human Body. 1918. FIG. 825. Cutaneous nerves of right lower extremity.
Front view. & FIG. 830. Posterior view.
4.7 Biomechanics

4.7.1 The tibiofemoral joint

The tibiofemoral joint is a combination between a pivot joint, also *articulatio trochoidea*, and a hinge joint, also *articulatio cylindroidea* or *ginglymus*, which is referred to as a trochoginglymus or bicondylar joint. It unifies a rolling and sliding movement of the involved joint bodies.

There are four movements possible around the vertical axis and the horizontal axis:

- **hinge joint**: extension (stretching) 5-10° – flexion (bending) 120-160°
  
  The femoral condyles are rolling in the early stages of flexion (up to 25°). The bigger the knee is bending, the rolling movements are stopped and the condyles glide progressively to the dorsal side. In maximum possible flexion, the contact surface between the upper and lower leg bones can be found at the posterior edge of the lower leg bone. The menisci move dorsally during flexion, although the lateral meniscus covers a longer distance due to its greater range of motion.

  Active flexion cannot exceed 125° due to insufficiency of the flexor muscles. By stretching the flexor muscles with additional flexion in the hip joint, a flexion of 140°
can be achieved. Passive flexion is limited to 160° by the compression of dorsal thigh and lower leg muscles. The extension can be up to 0°; passively an overstretching of 5-10° can be achieved. During extension, the menisci move back to the ventral. In neutral-zero position, they are pushed aside.

- **pivot joint**: external rotation 30-40° - internal rotation 10°
  In extension, rotations are prevented by the collateral ligaments. In flexed position (90°), the lower leg can be rotated more outward (about 30°), because the internal rotation is inhibited by the cruciate ligaments (up to 10°).
  During an external rotation, the lateral meniscus moves forward while the medial meniscus is moving backwards. During internal rotation, these movements are reversed.7,9

### 4.7.2 The patellofemoral joint

In the extended knee joint, the kneecap lies on the bursa suprapatellaris and only touches the articular surface of the thighbone with its lower edge.

During flexion, it glides caudally 5-7cm on the femur, with the resulting force is increasing and can be up to more than six times the body weight. Therefore, injuries and degeneration of retro-patellar cartilage are among the most common cartilage defects.7,9

The stability in the joint is given by complex interactions between osseous structures and soft tissues. There are three groups of stabilizers: the active stabilizers (quadriceps mechanism), the passive stabilizers (retinacula) and the static stabilizers (articular surface).

- **active stabilizers**: The distal vastus lateralis and vastus medialis of the quadriceps muscle structure stabilizes the medial-lateral patellar part with their oblique components. Decreasing tension of vastus medialis obliquus (VMO) is associated with patellofemoral malalignment; total loss effects significantly reduced lateral stability. Due to this, the VMO seems to be more important than other components of the extensor musculature.

- **passive stabilizers**: Warren et. al. described the differentiation of the tissue covering the medial part of the knee into three primary layers. The first layer is determined by the fascia compounding with the sartorius muscle and the most superficial one. The second layer is a bit more profound than the layer 1 and specified by the superficial component of the medial collateral ligament. The third and last layer is the deepest and the joint capsule. The medial patellofemoral ligament lies within layer 2 and runs from the medial epicondyle of the femur to the upper part of the medial margin of the patella. Some fibres of the MPFL commonly connect with the deep fascia of the
VMO. Research has shown that the MPFL is probably the most important passive tissue to prevent lateral patellar displacement. It supplies 50-60% of the restraining force. The medial patellomeniscal ligament seems to be another significant contributing passive tissue. Together with the MPFL, they allocate almost 75% of the restraining forces.

- **static stabilizers:** Varieties in geometry or morphology of the surface of the patella or the trochlea causes patellar instability. The patellar tendon tension withstands the strength of the quadriceps along the axis of the femur. They converge on an angle about 15°; it is called the quadriceps angle or Q-angle. As a resolution, there is a lateral force component on the patella, which is sustained by the lateral facet of femoral trochlea.

To measure this q-angle, a line has to be drawn from the anterior superior iliac spine (ASIS) to the center of patella and another one from the center of patella to the tuberositas tibiae. Standard Q-angle is 10° for men and 15° for women (±5°). Genu valgum, increased femoral anteversion, lateral positioning of the tibial tuberosity and tight lateral retinaculum are linked to an increase of the Q-angle. An increase of Q-angle goes along with enlarged lateral displacement force on the patella and may lead to dislocation.⁶ (Fig. 19)
4.8 Roux-Elmslie procedure

The Roux-Elmslie-Trillat procedure is a specific “distal realignment procedure”, also known as tibial tubercle transfer procedures or TTT. It was originally described by Roux (1888) and later modified by R.C. Elmslie in the 1900’s. In the year 1964 Trillat et al. published the procedure for the first time and popularized it. It includes a lateral retinacular release of the knee, medial capsular reefing and medial displacement of the infrapatellar tendon hinged on a distal periosteal attachment. During the surgery the tibial tubercle is cut and moved towards the medial side. However, the distal part of the tubercle must not be cut in order to maintain proper circulation, only the cervical part is moved. After temporary fixation sliding of the patella is tested through passive motion. If the alignment is correct the tibial tubercle will be permanently fixed. It is an easy learnt but effective technique with a low recurrence rate. Benefits are the minor distalization of the tibial tuberositas, the possibility to position the patella optimally in the slide bearing during surgery and an early functional postoperative treatment. Disadvantage could be the second intervention to remove the screws (usually in local anaesthesia possible). Also the heads of the screws can be troubling during genuflection.

Indications for this method could be recurrent and habitual patellar dislocations or lateralization of the patella without retro-patellar arthrosis. A surgery should be only performed, if a consistently performed conservative therapy (physiotherapy, ultrasound, iontophoresis, bandages, temporary antiphlogistic treatment, …) will not bring the required recovery. Contraindications are open epiphyseal plate of the proximal tibia, genu valgum (>10°) and infection of the operating area in the last three months.

Before surgery the patient has to be informed about the procedure (transfer of the tuberositas, retinacular release, maybe medial capsular reefing), all possible additional interventions (arthrotomy, cartilage abrasion, Pridie technique) and risks. In addition to the usual risks, pseudarthrosis, necrosis, swelling, recurrent dislocations and retro-patellar arthrosis are possible sequelae.

Pre-operative preparation should include anamnestic, clinical and radiological evaluation of the patient to estimate predisposing factors, which determine the necessary additional interventions. The patient lies in supine position with blood arrest around the thigh/upper leg of the affected knee. The knee is lightly flexed (positioning rolls). 12,13

4.8.1 Technique

The skin incision proceeds lateral and parapatellar downwards and terminates 4-5 cm below the tuberosity. (Fig. 20) After severing the ligamentum patellae longitudinale laterale about
1cm next to margin of the patella, the fibrous capsule is dissected from the synovial membrane (for better wound closure/healing) and an about 1cm broad part of the capsula is removed.

Fig. 20: Cox JS. Evaluation of the Roux-Elmslie-Trillat procedure for knee extensor realignment. American Journal of Sports Medicine. 1982;10(5):303-10. Fig. 2.

Adequate haemostasis is mandatory. Afterward blood control additional interventions can be performed, if they are required (arthrotomy, Pridie technique, drilling, joint cleaning, cartilage abrasion, ablation of osteophytes or loose bodies). An intraarticular Redon-drainage should be inserted and sutured. The synovial membrane is sewn continuously. The tibial margins are prepared to 5 cm distal to the tuberositas; the periosteum is split and shifted. A transverse drillhole is made (3.2mm drill) through the cortical bone 4-6 cm below the tuberosity and will serve as breakpoint later. The patellar tendon is pulled up with a fine Langenbeck-hook for protection. With a wide chisel, the bone chip is provided with a notch for the saw. The front margin of the tibia is osteotomized with an oscillating saw (under water cooling). In addition to the medialization a slight ventralization is possible by a medial rising sawing. The osteotomized bone shell is levered by approximately 1.5 cm to the medial side. If it is possible, the distal periosteal bone bridge should remain intact (osteoperiosteal bridge). The chip persists pediculated on the periosteum (periosteal bridge). (Fig. 21)
The medial cortical tibial edge is roughened with a chisel or luer to attach autologous cancellous bone chips. The medialized bone graft is kept in position until temporary fixation with drill wire (2.0mm thickness). Now, the alignment of the patella and sufficiency of the medialization can be checked by careful bending and stretching (correction of q-angle) and whether if any other abarticular additional interventions are necessary (capsula plication, distalization of the vastus medialis muscle). In order to permanently fix the bone chip, it is drilled proximally and distally at 90° to the contercortical bone, minding acceptable distance to the ends. The definitive fixation is done after drilling with a proximal spongiosa screw (2/3 6.5 mm) with a washer and a distal cortical screw (4.5 mm). Cancellous bone chips are deposited under the proximal part of the bone graft on the roughened cortical bone. (Fig. 22)

The displaced periosteum of the medial margin of the tibia is sutured to the bone chip. Laterally, a hemostyptic is placed on the spongy bone. An intraoperative X-ray control can be
performed as needed. After opening the tourniquet, careful haemostasis and inserting a Redon-drainage, the wound can be closed in layers.

In-patient rehabilitation should include X-ray control in 2 planes, elevation of the affected limb, cryotherapy, antiphlogistic medication and thromboprophylaxis. After 48 hours the bandage should be changed for the first time and the Redon-Drainage should be removed. The affected leg should be relieved for 6 weeks postoperatively. Likewise, the limitation of movement of 60°/0° (flexion/extension) is to be considered. In addition, physiotherapy is to be inherited. After 4 weeks lifting of the stretched leg is allowed while lying. The musculus vastus medialis can be trained with electrostimulation. The removal into outpatient treatment is possible after 10 to 14 days. Physiotherapy should be continued strictly, such as another X-ray control 6 weeks after surgery. The flexion should be increased carefully. Only after 12 weeks flexion without limitation is allowed.\textsuperscript{12,13}

In the original method fixation is indicated with only one screw. The use of 2 screws does not extent the procedure, but is safer and allows early postoperative treatment.\textsuperscript{13}
4.9 Evaluation assessments and examination methods

The International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form is a patient-oriented questionnaire that evaluates symptoms and function in daily living activities. (see appendix) It is considered to be one of the most reliable tools to measure outcome in its category. The questionnaire discusses 3 categories: symptoms, athletic activity and knee function. The subscale for symptoms assesses signs such as pain, rigidity, swelling and giving-way of the knee. Functions like going up and down the stairs, rising from a chair, squatting and jumping regard to the athletic activity. While the knees function subscale focuses on any subjective difference of the knee between now and prior to the injury. The score ranges from 0 to 100, compounding by the individual item-scores and transformed into a scaled number, while higher scores representing higher levels of function.\textsuperscript{14}

Kujala et al. found a new questionnaire, which was used to evaluate subjective symptoms, e.g. pain and swelling, functional limitations, abnormal painful kneecap movements and atrophy of thigh-muscles in patellofemoral disorders. (see appendix) The total score is 100 points with any symptoms or limitations. The worst value and therefore a strong restriction is at 0 points.\textsuperscript{15}

Lysholm et al. was first published in 1982 and is also a scoring scale for diseases or injuries of the anterior cruciate ligament or knee joint. (see appendix) In 1985 the questionnaire was revised and one item regarding knee locking, while removing other items. In eight questions it summarizes statements about physical function, pain and symptoms. Six items ask about physical function, one question is about the level of pain and the last one inquires any other symptoms. Score may vary from 0-100. Higher scores show a better outcome with fewer symptoms or disabilities.\textsuperscript{16}

The patellar instability severity score (PIS) was developed by a working group of the AGA (Society for Arthroscopy and Joint Surgery) to assess severity of patellar stability and exclude osseocartilaginous lesions after patellar dislocation. (Fig. 23) Six predisposing factors, such as age, trochlea dysplasia (after Dejour), patella alta (after Insall-Salvati) or patella tilt, are enquired to permit a reliable rating of a possible recurrence luxation. Each predisposal scores one point, except trochlea dysplasia. It is divided in mild (type A) and severe (type B, C and D) dysplasia. Mild dysplasia is valued with one point, while severe attains two points. Maximum achievable score is seven points. If there are four or more (\geq 4) predisposing factors revealed, there is a significant risk of reluxation.\textsuperscript{17,18}
The visual analogue scale (VAS) is a semi-quantitative method for the subjective measurement of sentiency strength (e.g. pain). The patient has to estimate his sensibility on a scale of 0 (no sentiency) to 10 (strongest conceivable sentiency). The scale is usually a bar or a distance given, on which the patient enters the sensation strength as a distance from the left edge. With repeated documentation this method gives an orienting overview over the temporal course and the success of a therapy.\textsuperscript{19} (Fig. 24)

The Short Form 36 (SF36) is a disease-non-specific measurement to register health-related quality of life. It compounds eight domains with overall 36 questions: general health perception (five questions), physical health (ten questions), restricted physical role function (four questions), physical pain (two questions), vitality (four questions), mental health (five questions), restricted emotional role function (three questions) and social functioning (two questions). The score ranges from 0 to 100 points. 0 points represent the greatest possible restriction of health, while 100 points represent the absence of health restrictions. The questionnaire does not consider the influence of sleep on the quality of life, which may be a possible weakness.\textsuperscript{20} (see appendix)
Lachman-manoeuvre is an assessment for clinical diagnosis of anterior cruciate ligament rupture and is always tested in both sides to compare results. It is a drawer test, in which the knee to be tested is held in about 20-30 ° flexion. The heel lies on the lounger. The examiner covers the lower leg with both hands; the forefingers are located in the popliteal fossa. The shank is pulled forward. The displaceability of the lower leg relative to the thigh indicates whether there is an injury of the cruciate ligament or not.21

Steinmann’s sign is a clinical examination to show up possible meniscal lesions. One hand of the examiner covers the heel, the other fixes the knee. In 90 ° flexion of the lower leg the examiner is passively rotating the shank inwardly and outwardly in the knee joint. Pain in external rotation and occurring at the medial joint gap suggests a lesion of the internal meniscus, while pain in internal rotation occurring at the lateral joint gap indicates damage to the external meniscus.21

Apley traction is a clinical bump test to detect meniscal lesions and or damage of collateral ligaments. The patient lies in abdominal position and angles one knee at right square (90 °). The therapist exerts pressure on the sole of the foot axially from above, turning the leg once inwards and once outwards. If pain appears in internal rotation, there may be an external meniscal lesion. Conversely, if pain appears in external rotation, an internal meniscal lesion is likely. Depending on the degree of flexion when performing the test, especially the posterior horn (> 90 °) or the anterior horn (<90 °) of the menisci is loaded.21

The range of motion (ROM) measures the active and passive mobility in a joint by neutral zero method.21

J-Sign is a clinical assessment to indicate lateral patellar tracking. The patient sits on the lounger with bended knees in 45° flexion. The physician instructs the patient to extend the knee, while evaluating the movement of the patella. If there is J-shaped patellar aberration to the lateral side, it may refers to patellar malalignment, vastus medialis oblique deficiency or increased Q-angle.21

Patella Apprehension Test is an instrument to detect whether the patella is prone to dislocate to lateral side. The patient lies on his back, the examined knee is extended. The physician pushes slowly and with gentle pressure against the medial side of patella, while moving it in a lateral direction. Due to the patient’s reaction, a conclusion can be drawn. If the patient reports discomfort or pain or tries to move away from pressure, a dislocation is likely.21
5. Objectives

Mainly young adults present to the emergency department with patellar dislocation. In order to prevent any further dislocations and consequential damages, such as cartilage lesions, pain, instability or restricted mobility, adequate therapy must be performed. The patient should not be further restricted in daily life or sports.

The main objective is if there were any re-dislocations in a patient’s history after surgery with Roux-Elmslie-Trillat-procedure. Subjective evaluation of the patient, raised by questionnaires and clinical assessment to show instability and ligament injuries or meniscal lesion, are among the side parameters. Radiological parameters through MRI and X-ray, such as trochlea dysplasia, and parameters of the gait pattern, e.g. walking speed, are included as well.

Null hypothesis: The subjective and objective clinical parameters and parameters of gait pattern are not equal to the ones of the healthy control group at the time of the follow-up examination after Roux-Elmslie-Trillat surgery.
6. Methods

6.1 Study design

This study is a clinical study conducted at the Department of Orthopedics and Traumatology, Clinical Division of Trauma surgery, at the Medical University of Vienna. 161 patients presented at the University Clinic and were treated with Roux-Elmslie-Trillat due to a chronic patellar dislocation in the period from 2010 to 2016. After dropping out all the patients, who didn’t match our inclusion criteria, 56 people were invited to participate. 13 patients responded and consequently were included in the study.

Exclusion criteria of the present study were single dislocation of the patella, fracture of the patella, knee instabilities or injuries (e.g. meniscal lesion, tear of the ACL [anterior cruciate ligament], cartilage damage) or further trauma in lower limbs, age (>50), BMI (>35kg/m²) or pregnancy.

Inclusion criteria of the present study were recurrent dislocation of the patella, patients with a Roux-Elmslie-Trillat procedure, intact patella, stable knee joint, age (<50) and BMI (<35kg/m²).

All patients were evaluated at the time of the follow-up with the Lysholm, the Kujala and the International Knee Documentation Committee (IKDC) score. The Patellar Instability Severity score (PIS) was calculated for every patient. Several x-ray radiographs were made: a/p view of the injured knee, a/p view standing of both legs and patella-defile view (in 30°, 60° and 90° flexion). MRT images in T2-weighted sequence of the knee reaching to the tuberositas tibiae were taken, in which the TT-TG (tibial tuberosity trochlea groove) distance, shape and position of the patella, as well as the Q-angles were measured. Furthermore, a gait analysis was performed on the patients in order to compare them with a healthy control group (á 25 patients) matched in age and sex.
6.2 Execution

6.2.1 Clinical assessment

Patients who have been operated because of chronical patellar instability in the years of 2010 – 2016 with procedure according to Roux-Elmslie-Trillat were identified through an analysis of existing medical records at the Department of Orthopaedics and Traumatology, Clinical Division of Trauma surgery, at the Medical University of Vienna. After identifying which patients are included in the study, the respective patients were invited to participate in the study. Those patients, who agreed to participate, were invited to take part in follow-up examination. A clinical follow-up was performed at the Clinical Division of Trauma Surgery at the Medical University of Vienna and consisted of a range of motion, pain and relaxuation testing. The following tests were conducted: IKDC score, Kujala knee function score, Lysholm score, PIS-score, rating of pain through VAS (visual analogue scale) and SF36. Patients were asked, if there were any events of re-dislocation. Lachman-manoeuvre, Steinmann’s sign, Apley traction, range of motion (ROM), J-Sign, Patella Apprehension Test, weight and height was measured during the clinical examination. BMI was calculated by weight and height of each person.

Patients will be excluded if they had further trauma or operation in the lower limbs.

The study was presented to the ethics committee and approved. Ethics vote: EK Nr. 1161/2016
6.2.2 Gait analysis

A 3D gait analysis was performed in the gait laboratory at the Department of Physical Medicine and Rehabilitation of the Medical University of Vienna. The aim was to analyse the gait pattern (spatio-temporal parameters as well as kinematic and kinetic data) of patients after Roux-Elmslie-Trillat procedure and those from a correspondent healthy control group. An informed consent of the subjects was obtained prior to the gait analysis.

In this non-invasive motion analysis technique 15 reflecting markers were precisely placed on specific body locations (Vicon Nexus, modified Helen Hays plug-in gait marker-set, 16mm diameter marker, hard, threaded, on a plastic base, Zurich, Switzerland) and their reflections were simultaneously recorded by eight infrared cameras (Vicon Nexus 1.7.1, Motion Systems Limited, MX T10 – Cameras, Oxford, UK, frame rate 200Hz) from different directions (Fig. 29). The markers were positioned on the left and the right anterior superior iliac spine, the position right between the posterior superior iliac spines, the left and right knee rotation axis on the lateral epicondylus of the knee, the left and the right ankle rotation axis on the lateral malleolus, the left and the right heel and forefoot as well as one marker laterally on each thigh and shank.

With this technique both the position and the motion of these markers can be captured in a three dimensional frame, which allows the continuous assessment of the joint angles of the transversal, the frontal and the sagittal plane. Before placing the markers, the width of pelvis, knees and ankles as well as the length of both legs had to be measured. Additionally, the walks were captured on film with high speed digital video cameras (Basler AG, Vision Technologies, Pilot, piA640-210gc, Ahrensburg, Germany, frame rate 200Hz) from the front and back side, respectively from the left and right side. At the same time ground reaction forces (GRF) were measured via force plates (AMTI, Watertown, MA, USA, exposure rate 1000Hz) that are located in the middle of the walk track, flush with the floor. These GRF provide the basis for inverse dynamic calculations which enables the software to calculate the joint moments. The detection of each walk both starts and stops via photoelectric barrier (ALGE-TIMING GmbH, Lustenau, Austria) which defines the size of the measuring volume.

After application of the markers, patients were instructed to walk barefoot and only wearing underwear, along the predefined distance of 8 m in the gait lab with self-chosen comfortable speed. For data acquisition a minimum of 6 evaluable walks were used. Each foot must hit the centre of the fully embedded force plates at least three times; no marker should be lost digitally.
The acquisition of the raw data and their processing was performed with specific gait analysis software (Vicon Nexus 1.7.1 and Polygon 4.1, Oxford, UK). For data analysis the mean values and standard deviations of all kinetic, kinematic and spatiotemporal variables of all participants were calculated and used for further calculations. All values displayed in polygon are exported in ASCII format as a text file; the gait events were saved in ASCII format as well. With the help of Excel Markos, the corresponding data was imported; maxima, minima and ROM were calculated and tabulated in Excel.\textsuperscript{22,23}

Walking is based on selective timing and the intensity of the respective muscles at each joint to provide stability during stress, shock absorption, support of the other foot while standing, to advance the swinging limb. Energy is saved by activating only those muscles that are optimally aligned for each task, and suppressing muscle activity as much as possible through momentum and passive tissue tension. Energy is saved by activating only the muscles optimally aligned for each task and by replacing direct muscle activity with impetus and passive tissue tension wherever possible.

Electromyography (EMG) is an electro-diagnostic medical method for assessing and recording the electrical activity generated by skeletal muscles. An instrument, called electromyography, is used to record a so-called electromyogram. The device detects the electrical potential produced by the muscle cells during their electrical or neurological activation. These signals can be used to detect medical abnormalities, activation level or recruitment order, or to analyze the biomechanics of human or animal movement.
There are two different methods to record an electromyogram:

- **surface EMG (SEMG):** This method is performed with adhered electrodes (e.g., on the skin surface). However, no conclusions on the activity of individual muscle fibers can be drawn here. The method is more suitable for determining the time delay between stimulus and muscle contraction.

- **needle EMG:** In this method, small needles that act as electrodes are pierced directly into the muscle. Thus, a much more accurate detection of the activity of individual muscle fibres is possible. For this purpose signal amplifiers are used. Computers can also convert these voltage differences into acoustic signals, which can then be perceived as noise, for example.

For gait analysis, like in this study, it is only important to assess if and when a muscle is active. This can be achieved via a threshold determination for the EMG signal.\(^\text{24}\)
6.2.3. MRI and X-ray

Additionally, all patients received a pre- and postoperatively MRI and x-ray examination of the knee. Both, the pre- and the postoperatively MRI should be performed at the same department. Through MRI of the knee, the TT-TG-distance was measured.

The position of the tibial tuberosity related to the trochlear groove is important for the inferolateral force vector of the patella. Although patellar instability is multifactorial, an increased tibial tuberosity-trochlear groove distance (TT-TG) is one of the possible factors contributing to lateral patellar instability.\textsuperscript{6,25}

The TT-TG distance is measured by overlaying transverse images of the apex of the intercondylar groove and the tibial tubercle. (Fig. 30) A line is drawn perpendicularly to the deepest spot of the trochlear groove and another one, also perpendicularly, to the centre of the patellar tendon insertion on the tuberosity of the tibiae.\textsuperscript{25}

A distance between the tibial tubercle and the trochlear groove of less than 15 mm is considered normal. A distance between 15 and 20 mm is on the borderline, and a distance of more than 20 mm indicates significant lateralization of the tuberosity.\textsuperscript{6,25}

In addition, the severity of chondropathy was determined due to the classification developed by the ICRS (International Cartilage Society).

Fig. 26: Axial image of the knee with superimposition of the tibial tubercle from another slice (yellow outline). The from the deepest point of the trochlea (line B) to the middle of the tibial tubercle (line A) is measured, again by using the posterior plane of the condyles as the reference line (line C).

Before conducting the X-ray examination, female patients of reproductive age were asked if a pregnancy is possible. If so, a pregnancy test was performed. If the result was positive, the patient was excluded from the study. The patients received a lateral and anterior-posterior (a/p) x-ray examination of the knee. Likewise, a/p view standing of both legs and patella-
define views (in 30°, 60° and 90° flexion) were taken. Through the x-ray the trochlea dysplasia has been analysed, as defined by the crossing sign and classification according to Dejour. (Fig. 31) Four types have been classified:

- Type A has a normal trochlear shape but with a shallow trochlear groove.
- Type B is characterized by marked flattening or convexity of trochlea.
- Type C is classified by trochlear facet asymmetry, a high lateral facet and a hypoplastic medial facet.
- Type D demonstrates characters of type C dysplasia but with a vertical connection between the facets, called the “cliff pattern”.

The crossing sign is seen on true lateral plain radiographs of the knee when the line of the trochlear groove crosses the anterior border of one of the condyle trochlea. It is a predictor of trochlear dysplasia. The crossing sign is sensitive but not specific in diagnosing trochlear-dysplasia; sensitivity of 94% and specificity of 56%. There are three types of crossing sign:

- type I (minor form): The condyles are symmetrical and have a high common point of intersection. The trochlea is sufficiently deep, but flatter than normal.
- type II: The condyles are asymmetrical and have separate points of intersection. The trochlea groove is shallow.
- type III (major form): The condyles are symmetrical and have a profound
common point of intersection. The trochlea is flat, there is no trochlea
groove.²⁶

A patellar tilt is a secondary sign of trochlear dysplasia, which prevents the disappearance of
the patella caused by the absence of the trochlear groove. The patella only articulates with its
lateral facet in the flat trochlea and is tilted therefore. On the other hand, a patella tilt can be a
sign of a patella alta as well, in which the patella is external rotated. In addition, increased
patellar tilt is often referred to as an unstable patella with a loose lateral retinaculum.¹⁷

The patella tilt angle is measured according to Fulkerson in suitable Patella defile images of
the patella with clearly visible femoral sulcus and posterior condyles. Next step is to draw
lines through the maximum width of the patella (1) and along posterior femoral condyles (2).
An auxiliary line is drawn parallel along to the posterior femoral condyles, which reveals an
angle with the line through the patella. (Fig. 32)

Normal values range from zero to five degrees (0-5°) and angles greater than ten degrees
(>10°) are considered as pathological. However, results over 20 degrees given through the
same measurement procedure are partially considered as strongly critical.²⁷

![Fig. 28: Patella Tilt](https://posterng.netkey.at/esr/viewing/index.php?module=viewimage&task=&mediafile_id=548135&201401072142.gif)

The Q-angle was measured of each patient through X-ray. Moreover, evidence of patella alta
was assessed in every patient according to the Insall-Salvati ratio.
6.3. Data set & Evaluation

Descriptive statistics (mean, median, standard deviation) was calculated using SPSS (SPSS, Chicago, IL). Fisher's exact test was used to show the significance of relaxation. Given normal distributed differences, paired two sample t-tests was performed for comparison of mean values between the two groups. In case of skewed differences, Wilcoxon matched-pairs signed ranks tests was performed. The Pearson correlation coefficient was used in order to detect correlations between age, gender, time-to-surgery and functional outcome parameters. For all tests a two-sided significance level of 0.05 (alpha) was set, causing a p-value of <0.05 to be statistically significant.

Microsoft Excel (Microsoft, Redmond, WA) and SPSS were used for data analysis and statistical calculations. Tables and graphs were used in order to better illustrate statistical parameter.

6.3.1 Parameters

**Main objective parameter**

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<tr>
<th>parameter</th>
<th>unit</th>
<th>variable type</th>
</tr>
</thead>
<tbody>
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<td>relaxation</td>
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<td>nominal</td>
</tr>
</tbody>
</table>

**Other parameters**

<table>
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<th>unit</th>
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</thead>
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<td>metric</td>
</tr>
<tr>
<td>Lysholm score</td>
<td>points</td>
<td>metric</td>
</tr>
<tr>
<td>Kujala score</td>
<td>points</td>
<td>metric</td>
</tr>
<tr>
<td>SF36 score</td>
<td>points</td>
<td>metric</td>
</tr>
<tr>
<td>VAS score</td>
<td>points</td>
<td>metric</td>
</tr>
<tr>
<td>PIS score</td>
<td>points</td>
<td>metric</td>
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<td>Steinmann-signs</td>
<td>pos/neg</td>
<td>nominal</td>
</tr>
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<td>Apley</td>
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<td>J-sign</td>
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</tr>
<tr>
<td>Patella Apprehension Test</td>
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</tr>
<tr>
<td>Dejour-Index</td>
<td>A, B, C, D</td>
<td>ordinal</td>
</tr>
<tr>
<td>Q-Angle</td>
<td>Degree</td>
<td>metric</td>
</tr>
<tr>
<td>TTTG-distance</td>
<td>cm</td>
<td>metric</td>
</tr>
<tr>
<td>Walking speed</td>
<td>km/h</td>
<td>metric</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td>stride</td>
<td>cm</td>
<td>metric</td>
</tr>
<tr>
<td>Knee Extensions Moment</td>
<td>Nm/kg</td>
<td>metric</td>
</tr>
<tr>
<td>Knee Flexion Moment</td>
<td>Nm/kg</td>
<td>metric</td>
</tr>
</tbody>
</table>

The scores (IKDC, Kujala, Lysholm, SF36, VAS) determine pain, impairment in everyday life and impairment of the active / passive movement. Lachman test, Steinmann-signs, Dejour index, Q angle and TTTG distance are parameters for the objective determination of the stability of the knee joint stability. Walking speed, crotch length, knee extension moment and knee flexion moment are parameters for assessing the gait. The secondary target parameters are recorded at the same time as the main target parameter.
7. Results

7.1 Subject

In this clinical study 13 patients were included, 7 of them were men and 8 women. One of them presented two times at the University Clinic and was treated with Roux-Elmslie-Trillat due to a chronic patellar dislocation in the period from 2010 to 2016 on both sides of the knee. 14 operated knees were included: 9 of them occurred at the left side and 5 at the right side of the patient.

The mean age of subjects was 30.2 (σ = 7.5), while the youngest one was 21 years old and the oldest was 52 years at the time of follow-up examination.

The mean BMI of all included participants is 24.5 (σ = 4.17), which was barely right on edge of normal weight. (mean of ♀=25.3; mean of ♂ =23.8) Highest measured BMI was 34.7, while lowest was 18.9.

The main question was if there was any event of re-dislocation. Only one patient represented a re-dislocation, which means one out of 14 operated knees had shown a further reluxation. (=7.14%) In the control group there were no patella dislocations. The prevalence of the patellar dislocation is not higher than in the control group.

All clinical assessments to show up meniscal or ligament injuries were negative in all patients, no lesions were detected. (Lachman, Steinmann, Apley)

The outcomes of range of motion between the healthy and the affected knee of the patients showed little difference in both sides, but there was no considerable difference in both groups.
The Patella Apprehension Test was negative in all patients. Positive J-sign was seen in two patients, the other eleven did not indicate a lateral deviation.

The participants were asked to state their average pain along a continuous line between two end-points (“no pain” – “worst pain imaginable”) in the affected knee according to VAS. The mean given pain scale is 2.3 (σ =2.2). Nine of the subjects claimed values less than or equal 3 (moderate, annoying pain). Four of them said they never have any pain. Highest stated pain was 6.5.

<table>
<thead>
<tr>
<th>Patient</th>
<th>ROM healthy knee</th>
<th>ROM affected knee</th>
</tr>
</thead>
<tbody>
<tr>
<td>p1</td>
<td>7-0-150</td>
<td>10-0-155</td>
</tr>
<tr>
<td>p2</td>
<td>0-0-125</td>
<td>0-0-120</td>
</tr>
<tr>
<td>p3</td>
<td>3-0-130</td>
<td>3-0-130</td>
</tr>
<tr>
<td>p4</td>
<td>10-0-140</td>
<td>12-0-140</td>
</tr>
<tr>
<td>p5</td>
<td>0-5-140</td>
<td>0-2-140</td>
</tr>
<tr>
<td>p6</td>
<td>5-0-135</td>
<td>5-0-140</td>
</tr>
<tr>
<td>p7</td>
<td>0-0-140</td>
<td>0-0-140</td>
</tr>
<tr>
<td>p8</td>
<td>0-0-165</td>
<td>0-0-170</td>
</tr>
<tr>
<td>p9</td>
<td>0-0-140 (right)</td>
<td>0-0-140 (left)</td>
</tr>
<tr>
<td>p10</td>
<td>0-0-130</td>
<td>0-0-130</td>
</tr>
<tr>
<td>p11</td>
<td>0-0-140</td>
<td>0-0-140</td>
</tr>
<tr>
<td>p12</td>
<td>3-0-140</td>
<td>0-0-135</td>
</tr>
<tr>
<td>p13</td>
<td>0-0-140</td>
<td>0-0-140</td>
</tr>
</tbody>
</table>

**Tab. 1: Range of Motion**

![VAS pain scale](image)

**Fig. 30: VAS**
The IKDC average score was 77.4 points (σ =14.5). Highest reached score was 95.4/100; while lowest result was 47.1/100.

Mean score of Lysholm amounted 87.5 points (σ =10.4). Highest measured result was 100, which was maximum attainable test score. The lowest given result was 69/100.

The Kujala mean score achieved 87.6 points (σ =8.8). Highest reached score was 98/100; while lowest result attained 70/100.

Mean outcome of SF36 totalled 77.7 points (σ =15.8). The highest result scored 93.4/100 and the lowest one 33.1/100.
7.2 Descriptive statistics

All patients have shown evidence of dysplasia in x-ray. Most of them manifested severe (type B or above) dysplasia (B – eight patients, C – two patients), some mild dysplasia (A – three patients) and none of them dysplasia type D.

Every patient has shown evidence of crossing sign, but only minor forms: type I (8 patients) or type II (5 patients). None of them has shown evidence a crossing sign type III.

---

**Fig. 31:** Dejour classification dysplasia type A-type D.

**Fig. 32:** Crossing sign type I- type III.
<table>
<thead>
<tr>
<th></th>
<th>age</th>
<th>operated knee</th>
<th>sex</th>
<th>height in m</th>
<th>weight in kg</th>
<th>BMI</th>
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<tr>
<td>p1</td>
<td>21</td>
<td>L</td>
<td>m</td>
<td>1.8</td>
<td>61.4</td>
<td>18.9</td>
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<tr>
<td>p2</td>
<td>31</td>
<td>R</td>
<td>w</td>
<td>1.68</td>
<td>98</td>
<td>34.7</td>
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<td>p3</td>
<td>25</td>
<td>R</td>
<td>w</td>
<td>1.66</td>
<td>65.4</td>
<td>23.7</td>
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<tr>
<td>p4</td>
<td>24</td>
<td>L</td>
<td>m</td>
<td>1.72</td>
<td>61.2</td>
<td>20.6</td>
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<td>w</td>
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<td>79.6</td>
<td>26.5</td>
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<td>R</td>
<td>w</td>
<td>1.62</td>
<td>64</td>
<td>24.3</td>
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<tr>
<td>p7</td>
<td>52</td>
<td>L</td>
<td>w</td>
<td>1.65</td>
<td>61</td>
<td>22.4</td>
</tr>
<tr>
<td>p8</td>
<td>29</td>
<td>L</td>
<td>m</td>
<td>1.84</td>
<td>67.2</td>
<td>19.8</td>
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<tr>
<td>p9</td>
<td>32</td>
<td>L+R</td>
<td>w</td>
<td>1.83</td>
<td>68.8</td>
<td>20.5</td>
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<td>p10</td>
<td>33</td>
<td>L</td>
<td>m</td>
<td>1.72</td>
<td>83</td>
<td>28</td>
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<tr>
<td>p11</td>
<td>33</td>
<td>L</td>
<td>m</td>
<td>1.86</td>
<td>87.8</td>
<td>25.3</td>
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<td>p12</td>
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<td>m</td>
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<td>87</td>
<td>25.1</td>
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<td>p13</td>
<td>32</td>
<td>L</td>
<td>m</td>
<td>2.05</td>
<td>120</td>
<td>28.5</td>
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Tab. 2: Age, sex, BMI of probands.

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<tr>
<th></th>
<th>relaxation</th>
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<th>Steinmann’s sign</th>
<th>Apley test</th>
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<td>neg</td>
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<td>no</td>
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<td>p3</td>
<td>yes</td>
<td>neg</td>
<td>neg</td>
<td>neg</td>
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<td>p13</td>
<td>no</td>
<td>neg</td>
<td>neg</td>
<td>neg</td>
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</table>

Tab. 3: Clinical assessment data.
Every patient has shown evidence of patella alta (Insall-Salvati ratio > 1.3) in x-ray before surgery. Measured values reached from 1.3 to 1.9; the average here was 1.5 (σ=0.19).

After Roux-Elmslie procedure every patient has shown minor improved results of Insall-Salvati index. The results ranged from 1.1 to 1.4; mean was 1.2 (σ=0.07). Two patients still achieved values above 1.3 despite amendment.

5 patients have shown a TT-TG distance above 15mm before surgery, 2 patients reached a value above 20mm. Data ranged from 8.7 and 24.4mm; the mean was 15.2mm (σ=4.56). After surgery a smaller TT-TG distance was measured in every subject’s MRI. None of the patients still showed a TT-TG distance larger than 20mm; only one patient still had a distance larger than 15mm. Results reached from 2.8 to 15.3; average TT-TG distance in this study was 8.5mm (σ=4.02).

Every patient presented a pathological patella tilt (>10°) before surgery, and even 8 patients have exceeded critical values over 20°. The mean was 22.1 (σ=5.98); values variety from 13.7 to 32.3. After surgery every patient, despite one, presented decreased patella tilt angles. Two patients still have exceeded critical results over 20°. Mean patella tilt was 16.9 (σ=4.05); data ranged from 10.2 to 21.7° post-surgery.
The mechanical axes of the legs of the patients were compared pre- and post-surgery. For the patient, who is affected on both sides, right side is noted first, then the left side.

<table>
<thead>
<tr>
<th></th>
<th>mechanical axis, healthy side preOP</th>
<th>mechanical axis, healthy side postOP</th>
<th>mechanical axis, affected side preOP</th>
<th>mechanical axis, affected side postOP</th>
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</thead>
<tbody>
<tr>
<td>p1</td>
<td>0.8 valgus</td>
<td>0.4 valgus</td>
<td>3.1 valgus</td>
<td>2.5 valgus</td>
</tr>
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<td>p2</td>
<td>2.3 valgus</td>
<td>1.1 valgus</td>
<td>0.9 valgus</td>
<td>1.2 valgus</td>
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<td>0</td>
<td>2.3 valgus</td>
<td>1.7 valgus</td>
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<td>p4</td>
<td>no pre imaging</td>
<td>0.4 valgus</td>
<td>no pre imaging</td>
<td>0.3 valgus</td>
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<td>1.8 valgus</td>
<td>1.4 valgus</td>
<td>0.9 valgus</td>
<td>0.4 valgus</td>
</tr>
<tr>
<td>p6</td>
<td>2.2 valgus</td>
<td>0.8 valgus</td>
<td>4 valgus</td>
<td>4 valgus</td>
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<tr>
<td>p7</td>
<td>4.7 valgus</td>
<td>4.6 valgus</td>
<td>2.5 valgus</td>
<td>0.9 valgus</td>
</tr>
<tr>
<td>p8</td>
<td>2.1 varus</td>
<td>2.3 varus</td>
<td>2.5 varus</td>
<td>2.9 varus</td>
</tr>
<tr>
<td>p9</td>
<td>0.2 valgus</td>
<td>0.5 valgus</td>
<td>1.8 valgus</td>
<td>1.7 valgus</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
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<td>1.8 valgus</td>
<td>no pre imaging</td>
<td>2.4 valgus</td>
</tr>
<tr>
<td>p13</td>
<td>3.4 valgus</td>
<td>0.9 valgus</td>
<td>2.0 valgus</td>
<td>2.7 valgus</td>
</tr>
</tbody>
</table>

Tab. 6: mechanical axis pre- and post-surgery
8 patients achieved 4 or more points in PIS-score before surgery. (mean= 3.8; σ=1.14) After surgery, every patient despite one, has a decreased PIS-score and now values under four. (mean= 2.5; σ=1.19)

After surgery no patient presented an abnormal Q-Angle more or equal than 20°.

The average follow-up time is 188.5 weeks (± 43.3 months or 3.6 years; σ= 80.3; range: 70–320)

<table>
<thead>
<tr>
<th>Crossing sign</th>
<th>Chondro-pathy preOP</th>
<th>PIS-score preOP</th>
<th>PIS-score postOP</th>
<th>Q-Angle postOP</th>
<th>Time since surgery-follow up in weeks</th>
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</thead>
<tbody>
<tr>
<td>p1</td>
<td>1</td>
<td>III</td>
<td>III-IV</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>p2</td>
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<td>III-IV</td>
<td>III-IV</td>
<td>1</td>
<td>0</td>
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<tr>
<td>p3</td>
<td>1</td>
<td>II</td>
<td>no post MR</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>p4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>p5</td>
<td>2</td>
<td>III-IV</td>
<td>III-IV</td>
<td>4</td>
<td>3</td>
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<td>III</td>
<td>III</td>
<td>3</td>
<td>2</td>
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<td>I</td>
<td>I-II</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>p8</td>
<td>1</td>
<td>I-II</td>
<td>I-II</td>
<td>5</td>
<td>5</td>
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<tr>
<td>p9</td>
<td>2</td>
<td>III-IV</td>
<td>III-IV</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>p10</td>
<td>2</td>
<td>III</td>
<td>III</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>p11</td>
<td>2</td>
<td>II-III</td>
<td>no post MR</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>p12</td>
<td>1</td>
<td>III</td>
<td>III-IV</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>p13</td>
<td>2</td>
<td>II-III</td>
<td>II</td>
<td>5</td>
<td>3</td>
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</tbody>
</table>

Tab. 7: abrasion, PIS-score, Q-Angle and follow up-time
7.3 Detailed analysis

The Fisher exact test statistic value was 0.359. The result of Fisher test of relaxation was not significant at p < .05. Patients treated with Roux-Elmslie procedure did not present significantly more events of dislocation after surgery. Due to that, the outcome after surgery was appropriate.

<table>
<thead>
<tr>
<th></th>
<th>relaxation</th>
<th>no relaxation</th>
<th>Marginal Row Totals</th>
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</thead>
<tbody>
<tr>
<td>Roux-Elmslie knees</td>
<td>1</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>control group</td>
<td>0</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Marginal Column Totals</td>
<td>1</td>
<td>38</td>
<td>39</td>
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</table>

Tab. 8: Fisher test: relaxation

There was no significant difference in walking speed between study group and control group.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>mean</th>
<th>standard deviation</th>
<th>standard error of the mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking Speed_inj</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>control</td>
<td>18</td>
<td>1,2733</td>
<td>0,12286</td>
<td>0,02896</td>
</tr>
<tr>
<td>Roux-Elmslie</td>
<td>12</td>
<td>1,1925</td>
<td>0,19887</td>
<td>0,05741</td>
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</tbody>
</table>

Tab. 9: Fisher test: walking speed

<table>
<thead>
<tr>
<th></th>
<th>Levene's Test for equality of variances</th>
<th>T-test for equality of mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>significance</td>
<td>95% confidence interval of difference</td>
</tr>
<tr>
<td>Walking Speed_inj</td>
<td></td>
<td>df</td>
</tr>
<tr>
<td>variances are equal</td>
<td>.290</td>
<td>28</td>
</tr>
<tr>
<td>variances are not equal</td>
<td>16,614</td>
<td>226</td>
</tr>
</tbody>
</table>

Tab. 10: Levene’s and T-test: walking speed

<table>
<thead>
<tr>
<th></th>
<th>T-test for equality of mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>95% confidence interval of difference</td>
</tr>
<tr>
<td>Walking Speed_inj</td>
<td></td>
</tr>
<tr>
<td>variances are equal</td>
<td>.20081</td>
</tr>
<tr>
<td>variances are not equal</td>
<td>.21673</td>
</tr>
</tbody>
</table>

Tab. 11: T-test: walking speed

There was no significant difference in maximum knee flexion (during a walk) between patients and control group.
### Table 12: Fisher test: maximum knee flexion

<table>
<thead>
<tr>
<th>group</th>
<th>n</th>
<th>mean</th>
<th>standard deviation</th>
<th>standard error of the mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>KneeFlexmaxLR_inj</td>
<td>18</td>
<td>17,6294</td>
<td>3,17622</td>
<td>,74864</td>
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<tr>
<td>control</td>
<td>18</td>
<td>17,6294</td>
<td>3,17622</td>
<td>,74864</td>
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<tr>
<td>Roux-Elmslie</td>
<td>12</td>
<td>12,3367</td>
<td>7,90861</td>
<td>2,28302</td>
</tr>
</tbody>
</table>

### Table 13: Levene’s and T-test: maximum knee flexion

<table>
<thead>
<tr>
<th>KneeFlexmaxLR_inj</th>
<th>Levene's Test for equality of variances</th>
<th>T-test for equality of mean sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>variances are equal</td>
<td>,011</td>
<td>,048</td>
</tr>
<tr>
<td>variances are not equal</td>
<td>,137</td>
<td></td>
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</tbody>
</table>

### Table 14: T-test: maximum knee flexion

<table>
<thead>
<tr>
<th>KneeFlexmaxLR_inj</th>
<th>T-test for equality of mean 95% confidence interval of difference bottom</th>
<th>top</th>
</tr>
</thead>
<tbody>
<tr>
<td>variances are equal</td>
<td>1,06320</td>
<td>9,52235</td>
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<tr>
<td>variances are not equal</td>
<td>,11763</td>
<td>10,46792</td>
</tr>
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Mann-Whitney-Test result showed no significant result. That means both populations are having the same distribution or rather the vastus medialis muscle of the study group activates to the same time as the one of the control group.

### Table 15: Mann-Whitney-Test: EMG Onset

<table>
<thead>
<tr>
<th>EMGVastmedON_inj</th>
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<tbody>
<tr>
<td>Mann-Whitney-U</td>
<td>71,000</td>
</tr>
<tr>
<td>Wilcoxon-W</td>
<td>137,000</td>
</tr>
<tr>
<td>Z</td>
<td>-0.839</td>
</tr>
<tr>
<td>asymptotic significance (2-sided)</td>
<td>,401</td>
</tr>
<tr>
<td>exact significance[2*(1-sided sig.)]</td>
<td>,422</td>
</tr>
</tbody>
</table>
8. Discussion

8.1 Interpretation

At the age of 10 to 17, the incidence rises up to 29/100.000. These patients are still young and have an entire life to build.\(^2\) Appropriate care is necessary to avoid subsequent damage and disability in everyday life or work life.

Null hypothesis: The subjective and objective clinical parameters and parameters of gait pattern are not equal to the ones of the healthy control group at the time of the follow-up examination after Roux-Elmslie-Trillat surgery.

Because of the not significant results of trial, the null hypothesis can be disproved and rejected.

There were not significantly more re-dislocations in trial group than in control group.

The average speed of study participants and control group is equally, due to that there is no impairment of walking speed. Also there is no difference during the flexion of the knee in the gait analysis. Thus the gait pattern of the control group and study group are the same.

Therefore, after Roux-Elmslie procedure there is no difference in gait pattern. The outcome after treatment with Roux-Elmslie procedure is sufficient.

Due to the fact that there is no pre surgery evaluation of patients, a comparison of subjective scores before and after surgery is not possible. A conclusion about changes in pain, sportive activities and limitation of daily life cannot be drawn.

Yet, most patients achieved high scores in evaluation. 7 patients achieve results more than 80 points in IKDC-score, 9 subjects exceed values over 80 points in Lysholm-score and 10 patients in Kujala-score. Subjective most patients would say the affected knee is now better than before surgery according to SF36 evaluation data.

In the 10 year follow up trial published by Endres et al Insall-Salvati index did change significantly. They measured values from 0.72-1.07 before surgery (mean= 0.85, \(\sigma\) =0.06) and 0.7-1.07 (mean=0.89, \(\sigma\) =0.08) after surgery.\(^4\)

In the present study higher Insall-Salvati were measured before and after surgery. The values range from 1.3 to 1.9 preoperative and average here is 1.5 (\(\sigma\) =0.19). The postoperative results range from 1.1 to 1.4; mean is 1.2 (\(\sigma\) =0.07).

Recent literature suggests that values higher than 1.5 refer to patella alta.\(^2\) According to this the outcome of Insall-Salvati ratio of every patient would be sufficient and no one would show an evidence of patella alta.
In the 26-year follow up study published by Carney et al one out of 15 affected knees had a recurrent relaxation (=7%). The mean of Lysholm score there was 67 points, the mean of Kujala score was 68 points and the mean of VAS-score was 4.8.3

In comparison with data of the present trial, also approximately 7% of patients experienced a recurrent dislocation. The mean score of Lysholm here was 87.5, which is more than in the trial of Carney et al. Also mean Kujala score of this study at 87.6 points, is higher score than in 26 year follow up. In addition, patients reported lower scores on the VAS, the mean is 2.3. The longest follow up period in this trial is about six years, which is not as long as compared to the follow up period in Carney et al. The question is, if there is a first improvement that will be followed by deterioration after many years.

Since we only got few answer to our invitations, it could be possible that most patients with any problems after surgery were not interested in follow up check and rather patients with resulting symptoms wanted get another examination. On the other side, the persons concerned are rather young. This could be the reason for the lack of cooperation.

Therefore a prospective study should be planned. If you could watch your own improve after surgery, it would be a possible reason for liability and more interest of patients.

Another point is the weight of patients. Most patients are young sporty people, but some of them are overweight. The overweight could influence the forces on the knee joint, which is not considered. Despite of that, overweight could be associated with knee issues, laxity and other pain. Latest research (Bout-Tabaku et al., 2014) disproves, that obese adolescents have a greater prevalence of pain in lower extremities or hypermobility and the combination of obesity and hypermobility is associated with more pain in lower extremities reported.30

The influence of overweight upon knee issues, especially patellar dislocation, is questionable. An open-ended question would be, if there is any difference in severity of trauma, which is necessary for patellar dislocation, or in any other parameters between normal weight subjects and obese patients.

Besides, there was only a little number of patients included in the study. This could be a reason for not finding any significance. Nevertheless, other publications did not have a way bigger group of study participants than the present trial. (Endres et al: 23 probands4, Carney et al: 15 knees3

Compared to the MPFL plastic surgery, a proximal soft tissues procedure, the Roux-Emslie procedure achieved almost the same results in the present study. In the study of Bouras et al 56 patients (57 knees) were evaluated. 35 of these were women and 21 men, median age was 23 years (σ =8.2, range: 14–47). The mean BMI of the patient was 29.5 (σ=6.4, range: 20–
48). So, the rather young and slightly overweight patient group of this study resembles them of the present. The mean follow-up period was 19.3 months (range: 12–53), which is shorter to the present study (43.3 months). The median Kujala score was 92 (range: 34–100), which is a bit better than in the present one (87.6 points). In the study of Panagopoulos et al 25 patients (19 men, 6 women) were examined. Average age was 26.9 years and mean follow-up period was 13 months, which is also little shorter than in the present study. There were no cases of re-dislocation recorded. IKDC scores were averaged 86.5. The mean Lysholm were 87 and Kujala scores 89 post-operative. The results are nearly identical (Lysholm: 87.5 points, Kujala: 87.6 points), only IKDC fares a bit better (present study IKDC: 77.4 points).

Both procedures have shown good outcome after surgery. However, it is not irrelevant which procedure is used. All patients need adequate examination. Proper treatment should depend on the clinic shown of the patient, predisposing factors and the malalignments of the knee or lower limbs. Not all procedures have the same indications, though surgeons often use their preferred technique.

There are no published papers on EMG data from Roux-Elmslie patients. Therefore, it is not possible to draw direct comparisons with the present data. Nevertheless, Asaeda et al. published a study, where they have analysed the gait kinematics and kinetics of patients treated with MPFL procedure. The results showed, that they have recovered by 1 year after MPFL-surgery (regarding to knee flexion angle and extension moment during gait). Besides, Smith et al. released a review on EMG activity of vastus medialis oblique (VMO) in patients with patellar instability. There were no papers, which assess EMG onsets of VMO in patients with patellar instability. Thus there is no robust evidence for a significant difference in the relative EMG onset of VMO or between affected and asymptotic knees.

In view of the lack of literature of, it cannot be verified if instability of the patellar is the consequence of atypical vastii activity. Therefore, it remains unsure from the study of Smith et al., whether if retraining of the quadriceps muscle is warranted for patients with patellar instability disorder, assuming modified vastus medialis obliquus and vastus lateralis recruitment.

Baksi et al. made EMG investigation of patients with an unstable patella before and after their realignment operation. Due to their article, VM showed subnormal activity preoperatively but it removed to normal in postoperative period. The present EMG-results showed no significant differences between the patients treated with Roux-Elmslie and the control group. So, the procedure’s outcome is sufficient. One can
assume that the gait kinematics and kinetics approximate to physiological conditions after a certain follow-up period.
8.2 Limitations

Unfortunately, only 14 patients were included in this study because of the lack of answers to the invitation. This could be a potential source of error because of the small size of the study group. Also, the study was done retrospectively; the check-ups before and after surgery were not carried out by the same examiner.

Patients did not get coherent physiotherapy and rehab. Additionally compliance of the patient during physiotherapy, especially workout at home, is not quantifiable.

Furthermore, the follow up-check is a different period after surgery (measured in time in weeks; from 70 to 320 weeks) for every patient. There could be improvement after a certain time post-surgery.

Activity und fitness-level was not quantified before surgery, an objective statement about difference to before surgery and improvement post-surgery is not possible.

The most patients in the study group are rather young. Thus the group could be too uniform. However most patients who present with patella luxation are young; the highest incidence rate is noted in the second decade of life (around 30/100.000) and decreases significantly after 30 years of age.36
8.3 Prospect

In the future a prospective study could be planned, where all data can be collected before and after surgery by the same examiner. Additionally, there should be uniform rehab to all subjects, as it would not be ethically acceptable to prohibit rehab for a control group, and a certain common period for a follow up check should be determined. Also there should be a questionnaire for physiotherapy exercises or other physical activity for rehabilitation done alone.

Physical activity should be measured, e.g. according to the International Physical Activity Questionnaire (IPAQ), before and after surgery. All scores (IKCD, Lysholm, etc.) should be evaluated before and after surgery.

Future trial should be planned in a longer period, there could be more patients included in trial, which would make it more meaningful.

Moreover, it would be interesting if there is a difference in parameters between just a few years after surgery and plenty years after surgery. Therefore, there should not be only one follow-up check, but rather more follow-up examinations after certain common periods for each patient.
9. List of References

1. **Fulkerson, JP.** Disorders of the Patellofemoral Joint. *Lippincott Williams & Wilkins.* 2004; 374.


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Fig. 30: Axial image of the knee with superimposition of the tibial tubercle from another slice (yellow outline). The from the deepest point of the trochlea (line B) to the middle of the tibial tubercle (line A) is measured, again by using the posterior plane of the condyles as the reference line (line C).

Fig. 31: Trochlear Dysplasia according to Dejour

Fig. 32: Patella Tilt

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Tab. 14: T-test: Maximum knee flexion.

Tab. 15: Mann-Whitney-Test: EMG Onset.
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACL</td>
<td>anterior cruciate ligament</td>
</tr>
<tr>
<td>ALL</td>
<td>anterolateral ligament</td>
</tr>
<tr>
<td>ASIS</td>
<td>anterior superior iliac spine</td>
</tr>
<tr>
<td>a/p</td>
<td>anterior/posterior</td>
</tr>
<tr>
<td>BMI</td>
<td>body mass index</td>
</tr>
<tr>
<td>EMG</td>
<td>electromyography</td>
</tr>
<tr>
<td>ICRS</td>
<td>International Cartilage Society</td>
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<td>IKDC</td>
<td>International Knee Documentation Committee</td>
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<td>IPAQ</td>
<td>International Physical Activity Questionnaire</td>
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<td>plica infrapatellaris</td>
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<td>FCL</td>
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<td>MPP</td>
<td>plica mediopatellaris</td>
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<tr>
<td>MRI</td>
<td>magnetic resonance imaging</td>
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<tr>
<td>PCL</td>
<td>posterior cruciate ligament</td>
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<tr>
<td>PISS</td>
<td>patellar instability severity score</td>
</tr>
<tr>
<td>RICE</td>
<td>rest, ice, compression and elevation</td>
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<tr>
<td>ROM</td>
<td>range of motion</td>
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<tr>
<td>SEMG</td>
<td>surface EMG</td>
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<td>Short Form Health 36</td>
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<td>plica suprapatellaris</td>
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<td>tuberositas tibiae-trochea groove</td>
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<tr>
<td>TCL</td>
<td>tibial collateral ligament</td>
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<td>VAS</td>
<td>visual analogue scale</td>
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<td>VMO</td>
<td>vastus medialis obliquus</td>
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## 12. Appendix

### 12.1 Questionnaires and Informed Assent

### 2000 IKDC Subjective Knee Evaluation Form

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Last</td>
</tr>
</tbody>
</table>

**Physician:**

**Date of Injury:**

### Symptoms:

*Grade symptoms at the highest activity level at which you think you could function without significant symptoms, even if you are not actually performing activities at this level.

1. What is the highest level of activity that you can perform without significant knee pain?
   - [ ] Very strenuous activities like jumping or pivoting as in basketball or soccer
   - [ ] Strenuous activities like heavy physical work, skiing or tennis
   - [ ] Moderate activities like moderate physical work, running or jogging
   - [ ] Light activities like walking, housework or yard work
   - [ ] Unable to perform any of the above activities due to knee pain

2. During the *past 4 weeks*, or since your injury, how often have you had pain?

<table>
<thead>
<tr>
<th>Never</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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</thead>
</table>
   |       |   |   |   |   |   |   |   |   |   |   | Constant

3. If you have pain, how severe is it?

<table>
<thead>
<tr>
<th>No pain</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>
   |          |   |   |   |   |   |   |   |   |   |   | Worst pain imaginable

4. During the *past 4 weeks*, or since your injury, how stiff or swollen was your knee?

   - [ ] Not at all
   - [ ] Mildly
   - [ ] Moderately
   - [ ] Very
   - [ ] Extremely

5. What is the highest level of activity you can perform without significant swelling in your knee?

   - [ ] Very strenuous activities like jumping or pivoting as in basketball or soccer
   - [ ] Strenuous activities like heavy physical work, skiing or tennis
   - [ ] Moderate activities like moderate physical work, running or jogging
   - [ ] Light activities like walking, housework or yard work
   - [ ] Unable to perform any of the above activities due to knee swelling

6. During the *past 4 weeks*, or since your injury, did your knee lock or catch?

   - [ ] Yes
   - [ ] No

7. What is the highest level of activity you can perform without significant giving way in your knee?

   - [ ] Very strenuous activities like jumping or pivoting as in basketball or soccer
   - [ ] Strenuous activities like heavy physical work, skiing or tennis
   - [ ] Moderate activities like moderate physical work, running or jogging
   - [ ] Light activities like walking, housework or yard work
   - [ ] Unable to perform any of the above activities due to giving way of the knee
SPORTS ACTIVITIES:

8. What is the highest level of activity you can participate in on a regular basis?
   - Very strenuous activities like jumping or pivoting as in basketball or soccer
   - Strenuous activities like heavy physical work, skiing or tennis
   - Moderate activities like moderate physical work, running or jogging
   - Light activities like walking, housework or yard work
   - Unable to perform any of the above activities due to knee

9. How does your knee affect your ability to:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Not difficult at all</th>
<th>Minimally difficult</th>
<th>Moderately difficult</th>
<th>Extremely difficult</th>
<th>Unable to do</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Go up stairs</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>b. Go down stairs</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>c. Kneel on the front of your knee</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>d. Squat</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>e. Sit with your knee bent</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>f. Rise from a chair</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>g. Run straight ahead</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>h. Jump and land on your involved leg</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>i. Stop and start quickly</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

FUNCTION:

10. How would you rate the function of your knee on a scale of 0 to 10 with 10 being normal, excellent function and 0 being the inability to perform any of your usual daily activities which may include sports?

FUNCTION PRIOR TO YOUR KNEE INJURY:

<table>
<thead>
<tr>
<th>Rating</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>No limitation in daily activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

CURRENT FUNCTION OF YOUR KNEE:

<table>
<thead>
<tr>
<th>Rating</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>No limitation in daily activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
KUJALA SCORING QUESTIONNAIRE

Name: [ ] [ ]  Date: [ ]

Physician: [ ]

1. Limp:
   ○ a) None
   ○ b) Slight or periodic
   ○ c) Constant

2. Support:
   ○ a) Full support without pain
   ○ b) Painful
   ○ c) Weightbearing impossible

3. Walking:
   ○ a) Unlimited
   ○ b) More than 2 km
   ○ c) 1-2 km
   ○ d) Unable

4. Stairs:
   ○ a) No difficulty
   ○ b) Slight pain when descending
   ○ c) Pain both when ascending and descending
   ○ d) Unable

5. Squatting:
   ○ a) No difficulty
   ○ b) Repeated squatting painful
   ○ c) Painful each time
   ○ d) Possible with partial weightbearing
   ○ e) Unable

6. Running:
   ○ a) No difficulty
   ○ b) Pain after more than 2 km
   ○ c) Slight pain from the start
   ○ d) Severe pain
   ○ e) Unable

7. Jumping:
   ○ a) No difficulty
   ○ b) Slight difficulty
   ○ c) Constant pain
   ○ d) Unable

8. Prolonged sitting with knee flexed:
   ○ a) No difficulty
   ○ b) Pain after exercise
   ○ c) Constant pain
   ○ d) Severe pain
   ○ e) Unable

9. Pain:
   ○ a) None
   ○ b) Slight and occasional
   ○ c) Interferes with sleep
   ○ d) Occasionally severe
   ○ e) Constant and severe

10. Swelling:
    ○ a) None
    ○ b) After severe exertion
    ○ c) After daily activities
    ○ d) Every morning
    ○ e) Constant

11. Abnormal painful kneecap movements:
    (patellar subluxations)
    ○ a) None
    ○ b) Occasionally in sports activities
    ○ c) Occasionally in daily activities
    ○ d) At least one dislocation after surgery
    ○ e) More than two dislocations

12. Atrophy of thigh:
    ○ a) None
    ○ b) Slight
    ○ c) Severe

13. Flexion deficiency:
    ○ a) None
    ○ b) Slight
    ○ c) Severe

Score [ ] [ ] [ ]

Print Form  Submit
<table>
<thead>
<tr>
<th>LYSHOLM SCORE (MODIFIZIERTER SCORE NACH LYSHOLM UND GILLQUIST)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HINKEN</strong></td>
</tr>
<tr>
<td>• nein</td>
</tr>
<tr>
<td>• wenig oder zeitweise</td>
</tr>
<tr>
<td>• stark oder immer</td>
</tr>
<tr>
<td><strong>BELASTUNG</strong></td>
</tr>
<tr>
<td>• Vollbelastung</td>
</tr>
<tr>
<td>• Gehstützen oder Stock</td>
</tr>
<tr>
<td>• Belastung nicht möglich</td>
</tr>
<tr>
<td><strong>BLOCKIERUNG</strong></td>
</tr>
<tr>
<td>• keine Blockierung und kein Gefühl der Einklemmung</td>
</tr>
<tr>
<td>• Gefühl der Einklemmung aber keine Blockierung</td>
</tr>
<tr>
<td>• gelegentliche Blockierung</td>
</tr>
<tr>
<td>• häufige Blockierung</td>
</tr>
<tr>
<td>• blockiertes Gelenk bei Untersuchung</td>
</tr>
<tr>
<td><strong>INSTABILITÄT</strong></td>
</tr>
<tr>
<td>• Niemals &quot;giving way&quot; Phänomen</td>
</tr>
<tr>
<td>• &quot;giving way&quot; selten während des Sports oder anderer schwerer Anstrengung</td>
</tr>
<tr>
<td>• &quot;giving way&quot; häufig während des Sports oder anderer schwerer Anstrengung (oder unmöglich, daran teilzunehmen)</td>
</tr>
<tr>
<td>• &quot;giving way&quot; gelegentlich während Tätigkeiten des Alltags</td>
</tr>
<tr>
<td>• &quot;giving way&quot; oft während Tätigkeiten des Alltags</td>
</tr>
<tr>
<td>• &quot;giving way&quot; bei jedem Schritt</td>
</tr>
<tr>
<td><strong>SCHMERZEN</strong></td>
</tr>
<tr>
<td>• keine</td>
</tr>
<tr>
<td>• unregelmäßig and gering während schwerer Anstrengung</td>
</tr>
<tr>
<td>• deutlich/ausgeprägt während schwerer Anstrengung</td>
</tr>
<tr>
<td>• deutlich während oder nach dem Gehen von mehr als 2km</td>
</tr>
<tr>
<td>• deutlich während oder nach dem Gehen von weniger als 2km</td>
</tr>
<tr>
<td>• ständig</td>
</tr>
<tr>
<td><strong>SCHWELLUNG</strong></td>
</tr>
<tr>
<td>• keine</td>
</tr>
<tr>
<td>• bei schwere Anstrengung</td>
</tr>
<tr>
<td>• bei gewöhnlicher Anstrengung</td>
</tr>
<tr>
<td>• ständig</td>
</tr>
<tr>
<td><strong>TREPPENSTEIGEN</strong></td>
</tr>
<tr>
<td>• kein Problem</td>
</tr>
<tr>
<td>• ein wenig beeinträchtigt</td>
</tr>
<tr>
<td>• Schritt für Schritt</td>
</tr>
<tr>
<td>• nicht möglich</td>
</tr>
<tr>
<td><strong>HOCKEN</strong></td>
</tr>
<tr>
<td>• kein Problem</td>
</tr>
<tr>
<td>• wenig beeinträchtigt</td>
</tr>
<tr>
<td>• nicht über 90°</td>
</tr>
<tr>
<td>• nicht möglich</td>
</tr>
<tr>
<td><strong>GESAMTPUNKTEZAHL</strong></td>
</tr>
</tbody>
</table>
IKDC CURRENT HEALTH ASSESSMENT FORM *

Your Full Name ____________________________________________________________

Your Date of Birth
Day/ Month/ Year

Today's Date
Day/ Month/ Year

1. In general, would you say your health is:  □ Excellent  □ Very Good  □ Good  □ Fair  □ Poor

2. Compared to one year ago, how would you rate your health in general now?

□ Much better now than 1 year ago  □ Somewhat better now than 1 year ago  □ About the same as 1 year ago

□ Somewhat worse now than 1 year ago  □ Much worse now than 1 year ago

3. The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

<table>
<thead>
<tr>
<th>Activities</th>
<th>Yes, Limited A Lot</th>
<th>Yes, Limited A Little</th>
<th>No, Not Limited At All</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Vigorous activities, such as running, lifting heavy objects,</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>participating in strenuous sports</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Moderate activities, such as moving a table, pushing a</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>vacuum cleaner, bowling, or playing golf</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Lifting or carrying groceries</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>d. Climbing several flights of stairs</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>e. Climbing one flight of stairs</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>f. Bending, kneeling or stooping</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>g. Walking more than a mile</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>h. Walking several blocks</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>i. Walking one block</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>j. Bathing or dressing yourself</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

4. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

<table>
<thead>
<tr>
<th>Problems</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Cut down on the amount of time you spent on work or other activities</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>b. Accomplished less than you would like</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>c. Were limited in the kind of work or other activities</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>d. Had difficulty performing the work or other activities (for example,</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>it took extra effort)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

<table>
<thead>
<tr>
<th>Problems</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Cut down on the amount of time you spent on work or other activities</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>b. Accomplished less than you would like</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>c. Didn’t do work or other activities as carefully as usual</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?
   - Not At All
   - Slightly
   - Moderately
   - Quite a Bit
   - Extremely

7. How much bodily pain have you had during the past 4 weeks?
   - None
   - Very Mild
   - Mild
   - Moderate
   - Severe
   - Very Severe

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?
   - Not at All
   - A Little Bit
   - Moderately
   - Quite a Bit
   - Extremely

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks...

<table>
<thead>
<tr>
<th>All of the time</th>
<th>Most of the time</th>
<th>A good bit of the time</th>
<th>Some of the time</th>
<th>A little of the time</th>
<th>None of the time</th>
</tr>
</thead>
</table>
   a. Did you feel full of pep? |   |   |   |   |   |
   b. Have you been very nervous? |   |   |   |   |   |
   c. Have you felt calm and peaceful? |   |   |   |   |   |
   d. Did you have a lot of energy? |   |   |   |   |   |
   e. Have you felt down-hearted and blue? |   |   |   |   |   |
   f. Did you feel worn out? |   |   |   |   |   |
   g. Have you been a happy person |   |   |   |   |   |
   h. Did you feel tired? |   |   |   |   |   |

10. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?
   - All of the time
   - Most of the time
   - Some of the time
   - A little of the time
   - None of the time

11. How TRUE or FALSE is each of the following statements for you?

<table>
<thead>
<tr>
<th>Definitely True</th>
<th>Mostly True</th>
<th>Don't Know</th>
<th>Mostly False</th>
<th>Definitely False</th>
</tr>
</thead>
</table>
   a. I seem to get sick a little easier than other people |   |   |   |   |
   b. I am as healthy as anybody I know |   |   |   |   |
   c. I expect my health to get worse |   |   |   |   |
   d. My health is excellent |   |   |   |   |

*This form includes questions from the SF-36™ Health Survey. Reproduced with the permission of the Medical Outcomes Trust, Copyright © 1992.*
PatientInnen-Information und Einwilligungserklärung

zur Teilnahme an der klinischen Studie

Ganganalyse bei Patienten nach operativ versorgter Patellaluxation

Sehr geehrte Teilnehmerin, sehr geehrter Teilnehmer!

Wir laden Sie ein an der oben genannten klinischen Studie teilzunehmen. Die Aufklärung darüber erfolgt in einem ausführlichen ärztlichen Gespräch.


Klinische Studien sind notwendig, um verlässliche neue medizinische Forschungsergebnisse zu gewinnen. Unverzichtbare Voraussetzung für die Durchführung einer klinischen Studie ist jedoch, dass Sie Ihr Einverständnis zur Teilnahme an dieser klinischen Studie schriftlich erklären. Bitte lesen Sie den folgenden Text als Ergänzung zum Informationsgespräch mit Ihrem Arzt sorgfältig durch und zögern Sie nicht Fragen zu stellen.

Bitte unterschreiben Sie die Einwilligungserklärung nur:

- wenn Sie Art und Ablauf der klinischen Studie vollständig verstanden haben,
- wenn Sie bereit sind, der Teilnahme zuzustimmen und
- wenn Sie sich über Ihre Rechte als Teilnehmer an dieser klinischen Studie im Klaren sind.

Zu dieser klinischen Studie, sowie zur Patienteninformation und Einwilligungserklärung wurde von der zuständigen Ethikkommission eine befürwortende Stellungnahme abgegeben.

1. Was ist der Zweck der klinischen Studie?

Der Zweck dieser klinischen Studie ist mittels retrospektiver Datenerhebung und klinischer Nachuntersuchungen die etwaige Unterschiede bezüglich der Ergebnisse von operativ versorgter Kniescheibenluxation aufzudecken und zu vergleichen, um eine mögliche Überlegenheit einer der beiden Methoden zu demonstrieren.

2. Wie läuft die klinische Studie ab?

Diese klinische Studie wird an der Universitätsklinik für Unfallchirurgie (Ebene 6c, Medizinische Universität Wien, Allgemeines Krankenhaus, Währinger Gürtel 18-20,

1090 Wien) durchgeführt, und es werden insgesamt ungefähr 50 Personen daran teilnehmen.

Ihre Teilnahme an dieser klinischen Studie wird voraussichtlich 2 Stunden dauern.

Folgende Maßnahmen werden ausschließlich aus Studiengründen durchgeführt:

Während dieser klinischen Studie werden am selben Tag die folgenden Untersuchungen durchgeführt: Ganganalyse, Kraftmessung, Überprüfung der freien passiven und aktiven Gelenksbeweglichkeit, Fragebogen ausfüllen, Röntgen, MRT Besprechung


3. Worin liegt der Nutzen einer Teilnahme an der Klinischen Studie?

Es ist möglich, dass Sie durch Ihre Teilnahme an dieser klinischen Studie keinen direkten Nutzen für Ihre Gesundheit ziehen. Es wird jedoch der aktuelle Zustand des Kniegelenkes anhand der klinischen Untersuchung sowie anhand des durchgeführten MRT gestellt und mit dem Patienten besprochen.

4. Gibt es Risiken, Beschwerden und Begleiterscheinungen?

Es sind von den im Rahmen dieser klinischen Studie durchgeführten Maßnahmen keine Beschwerden und Risiken zu erwarten. Sollten jedoch im Zuge der Nachuntersuchung grobe Defizite bekannt werden, werden die TeilnehmerInnen im Anschluss an die Untersuchung darüber in Kenntnis gesetzt und können bei Notwendigkeit eine Therapie erhalten.

5. Was ist zu tun beim Auftreten von Symptomen, Begleiterscheinungen und/oder Verletzungen?

Sollten im Verlauf der klinischen Studie irgendwelche Symptome, Begleiterscheinungen oder Verletzungen auftreten, müssen Sie diese Ihrem Arzt mitteilen, bei schwerwiegenden Begleiterscheinungen umgehend, ggf. telefonisch (Telefonnummern, etc. siehe unten).

6. Wann wird die klinische Studie vorzeitig beendet?

Sie können jederzeit auch ohne Angabe von Gründen, Ihre Teilnahmebereitschaft widerrufen und aus der klinischen Studie ausscheiden ohne dass Ihnen dadurch irgendwelche Nachteile für Ihre weitere medizinische Betreuung entstehen.

Ihr Studienarzt wird Sie über alle neuen Erkenntnisse, die in Bezug auf diese klinische Studie bekannt werden, und für Sie wesentlich werden könnten, umgehend
informieren. Auf dieser Basis können Sie dann Ihre Entscheidung zur weiteren Teilnahme an dieser klinischen Studie neu überdenken.

Es ist aber auch möglich, dass Ihr Studienarzt entscheidet, Ihre Teilnahme an der klinischen Studie vorzeitig zu beenden, ohne vorher Ihr Einverständnis einzuholen. Die Gründe hierfür können sein:

a) Sie können den Erfordernissen der Klinischen Studie nicht entsprechen;

b) Ihr Studienarzt hat den Eindruck, dass eine weitere Teilnahme an der klinischen Studie nicht in Ihrem Interesse ist;

7. In welcher Weise werden die im Rahmen dieser klinischen Studie gesammelten Daten verwendet?

Sofern gesetzlich nicht etwas anderes vorgesehen ist, haben nur die Studienärzte und deren Mitarbeiter Zugang zu den vertraulichen Daten, in denen Sie namentlich genannt werden. Diese Personen unterliegen der Schweigepflicht.

Die Weitergabe der Daten erfolgt ausschließlich zu statistischen Zwecken und Sie werden ausnahmslos nicht namentlich genannt. Auch in etwaigen Veröffentlichungen der Daten dieser klinischen Studie werden Sie nicht namentlich genannt.

8. Entstehen für die Teilnehmer Kosten? Gibt es einen Kostenersatz oder eine Vergütung?

Durch Ihre Teilnahme an dieser klinischen Studie entstehen für Sie keine zusätzlichen Kosten.

9. Möglichkeit zur Diskussion weiterer Fragen

Für weitere Fragen im Zusammenhang mit dieser klinischen Studie stehen Ihnen Ihr Studienarzt und seine Mitarbeiter gern zur Verfügung. Auch Fragen, die Ihre Rechte als Patient und Teilnehmer an dieser klinischen Studie betreffen, werden Ihnen gerne beantwortet.

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10. Einwilligungserklärung

Name des Patienten in Druckbuchstaben: .....................................................................................

Geb.Datum: ..................... Code: ...........................................................................................

Ich erkläre mich bereit, an der klinischen Studie teilzunehmen.

Ich werde den ärztlichen Anordnungen, die für die Durchführung der klinischen Studie erforderlich sind, Folge leisten, behalte mir jedoch das Recht vor, meine freiwillige Mitwirkung jederzeit zu beenden, ohne dass mir daraus Nachteile für meine weitere medizinische Betreuung entstehen.

Ich bin zugleich damit einverstanden, dass meine im Rahmen dieser klinischen Studie ermittelten Daten aufgezeichnet werden. Um die Richtigkeit der Datenaufzeichnung zu überprüfen, dürfen Beauftragte des Auftraggebers und der zuständigen Behörden beim Studienarzt Einblick in meine personenbezogenen Krankheitsdaten nehmen.

Die Bestimmungen des Datenschutzgesetzes in der geltenden Fassung werden eingehalten.


......................................................................................................................
(Datum und Unterschrift des Patienten)

......................................................................................................................
(Datum, Name und Unterschrift des verantwortlichen Arztes)

(Der Patient erhält eine unterschriebene Kopie der Patienteninformation und Einwilligungserklärung, das Original verbleibt im Studienordner des Studienarztes.)
12.2 Acknowledgement

With this diploma thesis I come to the end of my medical studies. The last few years have sometimes broken my nerves; however I have laughed a lot, learned new things and met great people. In addition, I was able to fulfil my lifetime dream of becoming a doctor with this study.

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Thank you.
12.3 Vita curae

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