Diplomarbeit

Correlation of the MRI-measured graft-angle after anterior cruciate ligament reconstruction with subjective and objective clinical outcome

Outcome of ACL reconstruction in the "all-inside" technique

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Graz, März 2014 *Dagma Thalhammer*

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Nomenclature

ACL	anterior cruciate ligament
AMB	anterior-medial bundle
BPTB	bone-patella-tendon-bone
cm	centimetre
e.g.	exempli gratia
HKB	hinteres Kreuzband
IKDC	International Knee Documentation Committee score
IKDCo	IKDC objective
IKDCs	IKDC subjective
KT1000®	Knee arthrometer® (MEDmetric, Corporation, San Diego, Calif)
lb	pound-force
MRI	magnetic resonance imaging
n	number of cases
N	Newton
ρ	significance
PCL	posterior cruciate ligament
PLB	posterior-lateral bundle
ROM	range of motion
SD	standard deviation
ST/G	Semitendinosus / Gracilis
Tegner	Tegner activity score
VAS	visual analog scale
VKB	vorderes Kreuzband
WOMAC	Western Ontario and McMaster Universities Arthritis Index score
WORMS score	Whole-organ magnetic resonance imaging score
z.B.	zum Beispiel

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1 Abstract in German

1.1 *Einleitung*

Die VKB -Ruptur ist in der Sportmedizin eine der wohl wichtigsten Verletzungen. Hinsichtlich des klinischen objektiven als auch subjektiven Ergebnisses nach Rekonstruktion, versuchten wir wichtige Faktoren zu analysieren, die bezüglich Operationswahl zukünftig berücksichtigt werden sollten. Wir konzentrierten uns auf die „all-inside“- in „outside-in“-Technik. Tatsache ist, dass diese Operationsmethode von geringerer Infektionsrate zu profitieren scheint. Überdies scheint das Risiko von physären Verletzungen minimiert zu sein (3). Aufgrund der posteromedialen Inzision oberhalb der Beugefalte resultiert auch ein besseres kosmetisches Ergebnis.

Die Methodik hat, im Vergleich zu anderen Techniken, abgesehen der höheren Kosten (2), folgende Vorteile: Entnahme nur einer Muskelsehne, vermehrte Bewegungsfreiheit in Flexionsstellung während der Bohrung, Verminderung des knorpeligen und knöchernen Schadens, beinahe physiologische Zustände hinsichtlich Eingang und Steilheit des Transplantats und „vermehrte Rotationsstabilität im Kniegelenk“ (22). Weiters scheint das Risiko hinsichtlich postoperativer Tunnelerweiterung und Abnützung („Ausleiern“) des Transplantats verringert zu sein.

Hinsichtlich Rekonvaleszenz scheint es keine Unterschiede zu anderen „klassischen“ OP-Techniken zu geben, obwohl die Schmerzintensität, welche durch die VAS Schmerzskala augenscheinlich gemacht werden kann, verringert zu sein scheint (1, 29).

1.2 *Studiendesign und Methodik*

Wir führten eine monozentrische, retrospektive Studie durch, die eine Kohorte von 48 Patienten umfasste. Alle Patienten wurden von einem Operateur im UKH Linz in Österreich mit der vorderen Kreuzbandplastik nach der „all-inside“–Methode in „outside-in“-Technik chirurgisch versorgt. Das Follow-up wurde mindestens ein Jahr nach der Intervention festgesetzt, um zu diesem Zeitpunkt die Stabilität des Knies überprüfen zu können.

Drop-out-Kriterien waren Reruptur des VKB, sowie Ruptur anderer Bänder im selben Knie, schwangere und stillende Frauen, Minderjährige und Patienten und Patientinnen mit magnetisierbaren Implantaten im Körper.
Nach einer klinischen Untersuchung wurden MRIs beider Knie angefertigt, um auch apparativ diagnostisch Schlüsse ziehen zu können. Die Bilder wurden anhand des WORMS Schemas bewertet. Überdies wurden Transplantat-, VKB und HKB-Winkel des operierten und des kontralateralen Knies vermessen.
Die statistische Auswertung erfolgte nach Gruppenzuteilung, wobei die Gruppe 1 mit einem Winkel < 47° und Gruppe 2 mit einem Winkel > 47° definiert wurde (Einteilung aufgrund (32)).

1.3 *Ergebnisse*

48 PatientInnen (17 Frauen und 31 Männer), im Schnitt 35 $\pm$ 12 Jahre alt, waren mit der Studienteilnahme einverstanden und unterzogen sich einer klinischen Untersuchung. Anhand der MRIs wurden die PatientInnen Gruppen zugeteilt, wobei Gruppe 1 als Transplantatwinkel <47° und Gruppe 2 als Transplantatwinkel > 47° definiert wurden.
In unserem PatientInnenkollektiv erscheint die Relation zwischen Transplantatwinkel und klinischem Ergebnis statistisch als signifikant unerheblich (p=0.7).
Hinsichtlich klinischem Ergebnis (IKDC + Tegner + WOMAC) ergab sich kein signifikanter Unterschied zwischen den Gruppen (ρ=0,99).
Auch hinsichtlich KT1000® (ρ=0,52) und des HKB-Winkels (ρ=0,298) ergaben sich keine signifikanten Unterschiede innerhalb der beiden Gruppen.
Hinsichtlich der Differenz zwischen Transplantat- und ACL-Winkel (ρ=0,002) und der Differenz den HKB-Winkeln (ΔPCL) (ρ=0,003) ergab sich jeweils ein signifikanter Unterschied.

1.4 *Null-Hypothese*

Es besteht eine Korrelation zwischen Transplantatwinkel und klinischem Ergebnis, gemessen am IKDC score.

Diese Hypothese konnte verworfen werden. Es besteht keine Korrelation zwischen Transplantatwinkel und klinischem Ergebnis, gemessen am IKDC:

1.5 *Sekundäre Hypothese*

Es besteht eine Korrelation zwischen Transplantatwinkel und der Stabilität, gemessen am KT1000® und am Pivot-Shift-Test.

Die Hypothese konnte verworfen werden. Es besteht keine Korrelation zwischen Transplantatwinkel und der Stabilität, gemessen am KT1000® und am Pivot-Shift-Test.

1.6 *Diskussion*

Das Ziel der Studie war, den Einfluss des Transplantatwinkels nach VKB-Rekonstruktion nach der “all-inside” – Methode in Bezug auf das klinische Ergebnis, gemessen anhand klinischer Scores (IKDC, Tegner, WOMAC) und anhand der Stabilität, gemessen am Pivot-Shift-Test und am KT1000®, zu evaluieren.

Die Hypothese war, dass der Transplantatwinkel dieses gemessene Ergebnis signifikant beeinflussen würde. Wir fanden heraus, dass das klinische Ergebnis und die Stabilität in unserem PatientInnenkollektiv nicht vom gemessenen Transplantatwinkel beeinflusst wurden.

Verschiedene Studiengruppen (33, 34) hatten versucht, objektive Parameter herauszufinden, die auf das klinische Ergebnis und auf die Stabilität oder die Laxizität nach VKB-Rekonstruktion Einfluss nehmen könnten.
Unsere Hypothese, dass der Transplantatwinkel das klinische Ergebnis beeinflussen könnte, konnte nicht verifiziert werden.
Entsprechend früherer Untersuchungen, nehmen wir an, dass die anatomische Rekonstruktion der wesentliche Parameter ist, um ein adäquates Ergebnis nach VKB-Rekonstruktion zu erzielen (33, 36). Hinsichtlich der anatomischen

Rekonstruktion dürfte der Transplantatwinkel in verschiedenen Kniegelenken aufgrund verschiedener Relationen hinsichtlich Tiefe und Breite variieren (34).

Hinsichtlich Transplantatwinkel wurden ähnliche Winkelverhältnisse wie in der Studie von Seo et al. (22) errechnet.
Hinsichtlich klinischem Ergebnis nach VKB-Rekonstruktion wurden Werte augenscheinlich, die vergleichbar mit Ergebnissen anderer Studien (29, 33, 35) waren.
Neben insgesamt 3, vor der Untersuchung verifizierten, Rerupturen, wurden während dem stationären Aufenthalt lediglich temporäre Komplikationen evident. Dabei handelte es sich um 1 aufgetretenen Infekt, der erfolgreich antibiotisch behandelt wurde und weiters wurden 4 Gelenkspunktionen und 1 Blutblaseneröffnung durchgeführt.
Mit Durchführung der studienassoziierten MRIs konnten noch 2 weitere Rerupturen und 1 Ruptur eines anderen Ligaments festgestellt werden.

1.7 *Limitationen*

Die Studie ist zu diesem Zeitpunkt noch underpowered (*n* ist zu gering).
Auch eine weitere Grössenunterteilung der Winkel hätte von Vorteil sein können.
Weiters könnte die Nicht-Differenzierung zwischen isolierter ACL- und kombinierter Ruptur mit anderen ligamentären Strukturen im Knie eine Rolle gespielt haben.
Da das Follow-up 1 Jahr postoperativ festgesetzt worden war, konnten wir über Langzeitergebnisse keine Auskunft geben.

1.8 *Schlussfolgerung*

Die Steilheit des Transplantatwinkels scheint keinen Einfluss zu haben, weder auf das klinische Ergebnis noch auf die Stabilität des Knies, obwohl die Studie zu diesem Zeitpunkt underpowered war.

2 Abstract in English

2.1 *Introduction*

The ACL rupture is one of the most important incidences in sports medicine.
In regard to the clinical outcome we tried to analyse some important facts that should be considered in choosing the operation technique.
We concentrated in performing the “all-inside”- in “outside-in” technique that is, compared to the “classic” techniques, almost very new in Europe. This technique seems to be effective and seems to profit advantageously in decreasing the infectious risk. Moreover it seems to minimize the risk of physeal injury (3).
Compared to other techniques and apart of the aspect of higher costs (2), this procedure has following advantages: harvesting of just one tendon, having more latitude regarding the flexion while drilling, decreasing cartilaginous and bone damage, having almost physiological conditions regarding inlet and steepness of the graft and having “superior knee joint rotational stability” (22). Moreover the risk of postoperative tunnel widening and slicking of the graft seems to be decreased.
Regarding convalescence there seems to be no difference to the other “classic” techniques although the pain level seems to be decreased at well after this kind of intervention (1, 29) made evidently by the VAS pain score. Because of the posteromedial incision barley superior to the flexion fold this procedure results in a better cosmetic outcome.

2.2 *Material and Methods*

We performed a monocentric, retrospective cohort study, including 48 patients.
All patients underwent treatment in UKH Linz in Linz, Austria. All patients were operated on by one single surgeon using the ACL reconstruction “all-inside” in “outside-in” technique. The follow-up was performed at least one year after intervention, to be able to examine the stability of the knee.
Drop-out-criteria were a re-ruptured ACL, lesions of other ligaments in the same knee, pregnancy, breast-feeding women, minors and men and women with fixed magnetisable implants in their body.
In addition to a clinical examination MRIs of both knees were done, to be able to draw apparatious diagnostic conclusions as well. These were analysed through

the WORMS-score. In addition to that the graft-, ACL- and PCL angles of the operated as well as the contralateral knee were measured.
Allocation in groups happened according to the graft angle whereby group 1 was defined as an angle<47°and group 2 as an angle>47°.

2.3 *Results*

48 patients (17 women and 31 men) at the mean age of 35 (SD±12) years, agreed in the study and underwent clinical examination. By assessment of the MRIs the patients were allocated to groups whereas group 1 was defined as a graft angle <47° and group 2 was defined as a graft angle >47°.
In our cohort the relation between graft angle and clinical outcome was statistically insignificant (p=0,7).
Regarding the subjective outcome (IKDC + Tegner + WOMAC) there was no statistical significance (p=0,99) between these groups.
Regarding the KT1000® (ρ=0,52) and the PCL angle (ρ=0,298) there was no significant difference between these groups.
Regarding the difference between graft- and ACL angle (ρ=0,002) and the difference between the PCL angles (ΔPCL) (ρ=0,003) there was a significant difference in each aspect.

2.4 *Primary hypothesis*

There is a correlation between the graft angle and the clinical outcome, measured by the IKDC score.

This hypothesis could be refuted. There is no correlation between the graft-angle and the clinical outcome (IKDC score).

2.5 *Secondary hypothesis*

There is a correlation between the graft-angle and stability, measured by the KT1000 and pivot-shift-test.

The hypothesis could be refuted. There is no correlation between the graft-angle and stability, measured by the KT1000 and the pivot-shift-test.

2.6 *Discussion*

The aim of this study was to evaluate the impact of the graft angle after ACL reconstruction in the "all-inside" technique on the clinical outcome, measured by clinical scores (IKDC, Tegner, WOMAC), and on stability, measured by the pivot-shift-test and KT1000®.

The hypothesis was, that the graft angle would significantly influence this measured outcome. We found, that the clinical outcome and stability was however not influenced by the measured graft angle.

Various study groups (33, 34) have tried to find objective parameters, which might influence the clinical outcome and stability or laxity after ACL reconstruction.
Our hypothesis, that the graft angle would significantly influence the outcome could not be verified. According to previous investigations, we therefore believe, that the anatomic reconstruction is the major parameter influencing adequate outcome after ACL reconstruction (33, 36). In case of an anatomic reconstruction, the graft angle might differ between different knee joints because of the different relation between depths and widths (34).

In group1 a mean graft angle of 38,9 $\pm$ 6,4° could be measured while in group 2 there was a mean graft angle of 51,6 $\pm$ 3,1° obvious. Similar angle constellations can be found in the study performed by Seo et al. (22).
Regarding the clinical outcome after ACL reconstruction similar results were analysed by other authors (29, 33, 35).

Beside 3 (before examination) verified re-ruptures while ambulant treatment only temporary complications became evident while stationary stay. That is a matter of 1 endured infect that was successfully antibiotically treated and moreover 4 knee joint punctures and 1 lancing of a blood blister were performed.

By performing the study-associated MRIs 2 other re-ruptures and 1 rupture of another ligament could be identified.

2.7 *Limitations*

At that moment the study was still underpowered (*n* is too low).
A further sizing regarding the graft angle could have revealed better results.
Another limitation could have been the fact that we did not differ between isolated ACL ruptures and those combined with other ligamental lesions although at the time of the follow-up there should not have been any difference regarding knee stability.
So far no long-terms-effects could have been examined.

2.8 *Conclusion*

The steepness of the graft angle seems to have no influence whether on the clinical outcome nor on the stability of the knee although at that time the study was underpowered.

3 Introduction

Anterior cruciate ligament (ACL) rupture is still one of the most important traumatic injuries in sports medicine. Despite of many discussions concerning the urge of surgery in history it is a fact that, in regard of high sports activity level and subjective discomfort, all this adjuncts to arthrocare, there is a need to an appropriately immediate intervention to reconstruct almost physiological proportions in the knee.

Regarding the surgical site, we concentrated in the “all-inside” in “outside-in” technique which seems to be mild in treatment and in fact it seems to profit advantageously in reducing the risk of infections.

Regarding the single bundle method, the advantage of the “outside-in”-technique is seen in the withdrawal of just one tendon, in having more latitude regarding the flexion while drilling, in decreasing cartilaginous and bone damage and in having almost physiological conditions regarding inlet and steepness of the graft. Furthermore the risk of postinterventional tunnel widening and slicking of the graft is decreased, thanks to the press-fit-fixation (by using the Allograft-OATS®-Technique (Arthrex, Inc.)) that ensures 360° (all around) contact area between graft and bone. Moreover Seo et al. claim that this technique has “superior knee joint rotational stability compared to the transtibial technique” (22) regarding single bundle reconstruction.

Regarding convalescence-time no differences could be found in literature so far although, regarding pain experiences, the “all-inside”-technique seems to be in advantage to other classic techniques (1, 29).
Indeed it is more expensive compared to other techniques (2) and larger knees seem to profit from the double bundle technique.
The aspect of angle-constellations in the knee is an almost new but important topic that has recently aroused interest in orthopaedic surgery. Diversities in angle constellations seem to have great influence regarding the postinterventional outcome and secondary morbidities.

Illingworth et al. (13) published 2011 the first relevant literature regarding ACL-angles we patterned ourselves to gain more focus to this topic.
In addition Freddy H. Fu declared in his presentation at ISAKOS, Toronto 2013 an ACL angle with an average of about 47° as a standard (group allocation because of (32)).

Assuming that the grafts were placed too steep yesterdays we assumed that regarding the subjective and clinical outcome an almost physiological placed graft angle would be the best profit for patients. Therefore we examined diversities between graft angle and the contralateral ACL angle. Moreover correlations of the IKDC score, KT1000® scores, pivot-shift-test, (PCL) angles of reconstructed and contralateral cruciate ligaments were examined.

We examined a range of 48 patients regarding their magnetic MRI-measured graft angle in relation to the tibial plateau, the ACL/PCL angles and other features as explained above. In addition clinical examinations were performed, to be more exact subjective (IKDCs, WOMAC score, Tegner-score) and objective tests (IKDCo), to be able, to compare several statements regarding the subjective and objective outcomes.

4 Anterior Cruciate Ligament

4.1 *Anatomy*

4.1.1 Fibers

Ligaments are mostly composed of type I collagen. They receive uniform microvascularity at insertation site. Moreover they have mechanoreceptors and free nerve endings.

Ligamental insertation into bone goes either direct or indirect:

- Superficial fibers insert at acute angle into the periost.
- Deep fibers attach at 90° angle. This transition occurs in 4 phases: ligament, fibrocartilage, mineralized fibrocartilage and bone (Sharpey´s fibers).

Healing (in 3 phases: inflammation, repair, remodelling) benefits from normal stress level and steady strain across the joint.

Early healing happens via collagen type III that are later converted into type I.

Rupture represents a torn sequential series of collagen fiber bundles all over the ligamental body. Adults are prone to midsubstance ligament tears while children are prone to avulsions (between the un- and mineralized fibrocartilaginous zone).

4.1.2 Origin and insertion

The ACL that runs (as the posterior cruciate ligament (PCL)) extra-capsulary has its origin in the Area intercondylaris tibia where anterior fibers transition into the transverse meniscal ligament.

Its insertion is in the intercondylar notch in the posteromedial corner of the medial side of the Condylus lateralis femoris where it is attached indirectly.

Femoral attachment of ACL is on posterior part of medial surface of lateral condyle (posterior to longitudinal axis of the femoral shaft).

Perfusion happens through the middle genicular artery, innervations through the tibial nerve.

4.1.3 Bundles

The ACL consists of the anteromedial bundle (AMB) and the posterolateral bundle (PLB), named for their insertion points on the tibial footprint, to be more exact its fibers attach medial or lateral of the Eminentia intercondylaris.
In flexion the AMB tightens while the PLB loosens and each acts vice versa in extension.
In extension the bundles themselves shift from parallel to crossed orientation in 90° of flexion.

4.1.3.1 Anteromedial bundle

The femoral insertion of the AMB represents the center of rotation.
It is more prone to injuries when knee is in flexion and it represents the primary check in the anterior Drawer-test.
Rupture may cause an increase of anterior translation in flexion, minimal increase in hyperextension, and minimal rotational instability.

4.1.3.2 Posterolateral bundle

PLB rupture causes increase of hyperextension. There seems to be an increase of external rotation with the knee in mid flexion while in extended condition anterior translation and external and internal rotation seem to be increased.

4.1.3.3 Intermediate bundle:

It seems to have no noticeable effect on biomechanical behaviour.

4.1.4 Tibiofemoral joint

A study performed by Haschemi et al. (16) shows that articular surfaces of the tibiofemoral joint play an important role regarding biomechanical behaviour. The asymmetric geometry of the tibial plateau and its tibial slope seem to have a “direct influence in terms of translation, the location of instantaneous center of rotation, the screw-home mechanism, and the strain biomechanics of the knee ligaments” (16) such as the anterior cruciate ligament. Regarding transition from

non-weight-bearing to weight-bearing activities, this tibial slope, "...defined as the angle between the perpendicular to the middle part of the diaphysis of the tibia and the line representing the posterior inclination of the tibial plateau" (16), seems to directly affect anterior translation by increasing.
Some studies suggest that women and ACL injured patients had smaller conditions regarding ACL volume and notch geometry and steeper posterior tibial slopes. They also see the notch width at the inlet as a good predictor to injuries. (17, 23) Also Evans et al. (19) conclude from their study regarding BMI narrow notch width and non-contact ACL injuries as significant correlations while van Eck et al. (20) found correlations between notch volume to height, weight and gender but no correlation to BMI (body-mass-index).

Tibial and femoral anatomic conditions are very important when it comes to drill the sockets (tunnels). Position of a tibial socket is anatomically found between the AMB and the PLB of the ACL or at the center of the tibial insertion site of the ACL. "The anatomic position of a femoral socket is away from the posterior margin of the femoral ACL footprint by the same distance between the anterior margin of the ACL footprint and the center of the tibial tunnel when the knee is in 90° flexion" (20).
The quadrant method suggests the outside-in technique as effective for almost anatomical femoral tunnel placement (20).
Disadvantages regarding this technique may be seen in bigger knees that are prone to double-bundle-techniques and missing long-term-effects so far.
Moreover outcome seems to be similar to the "classic" techniques that are already manifest in yesteryear.

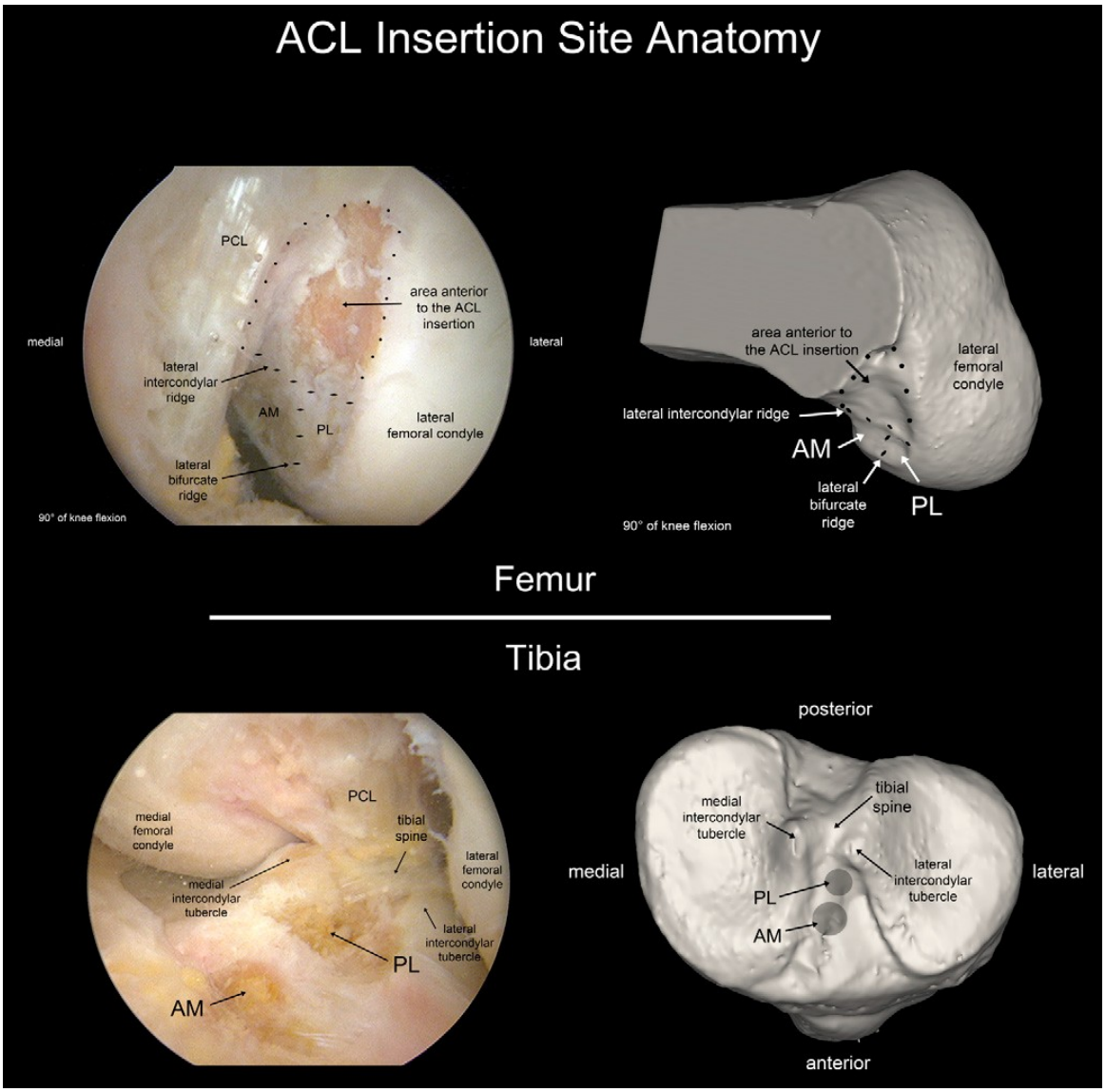

Figure1 – physiological tibial and femoral insertion site

Source:http://www.upmcphysicianresources.com/files/dmfile/Forsythe_JBJS_2010.pdf

4.2 *Physiology*

The ACL is very important for the stabilization of the knee restraining the anterior translation of the tibia, preventing hyperextension of the knee, stabilizing the knee against valgus forces and restraining tibial rotation. Moreover it is important because of its proprioceptive function.

The AMB is tensioned in flexion, while the PLB is tensioned contrarily in extension. In flexion both bundles cross themselves while they are almost parallel to each other in extension.

The proprioceptive function was main topic in different studies yesterdays. These studies deal with the healing aspect of preserved remnants of the ACL in reconstruction surgery to be more exact that remnants can help reinnervate the ACL graft by early revascularization. Sun L. et al. (7) described an “enhanced healing potential with improved biomechanical properties” in their rabbit model and Qu F. et al. (6) described “the clinical effect ... by preserving remnants” as “satisfactory”.

4.3 *ACL lesions*

Concerning sports medicine a strained ligament, laceration and ruptures occur as typical acute injuries.
A torn ACL is mostly present after a twisting and / or hyperextensive traumatic force (soccer, skiing etc.).
It is frequently accompanied by meniscal or medial collateral ligament lesions. Combination of all the three ligamental ruptures is called the “unhappy triad”.

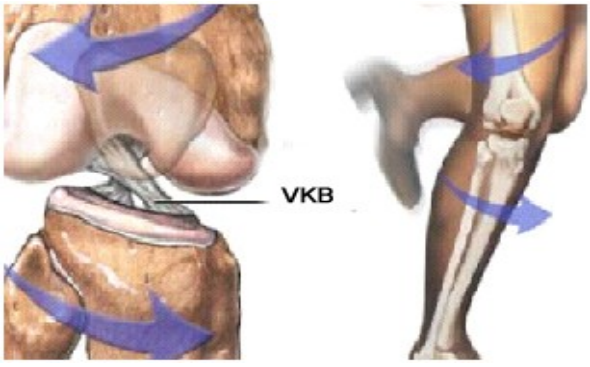

Figure2 – traumatic course of event

source: http://www.orthopaeden-langwasser.de/chirurgie.html#kreuzbandplastik

A chronic deficiency is represented by the ACL-insufficiency that is seen as a slicking of the ACL. In this case the PCL is angulated which leads to a chronic

tibial subluxation. Hashemi et al. (16) suggest that decreasing the tibial slope of the tibiofemoral joint might be useful in this kind of manner.

4.4 *Examination*

To be able to indicate a lesion in the knee, following aspects should be considered whereby the practise is dependent on the examiner (12):

4.4.1 Anamnesis

- Traumatic course of event → there are typical preferred sport-activities (e.g. skiing, soccer)
- Hear or feel of the rupture while injury
- Effusion or swelling
- Pain experience
- Deficiency in flexion or extension

4.4.2 Inspection and examination

- Effusion → e.g. Haemarthros as a typical sign of ACL- rupture
- Discoloration
- Visible signs of injury
- Atrophy of the femoral muscles → an unilateral circumference of the thigh as a sign for a chronic ligamental injury
- ROM → flexion and/or extension are mostly end-ply painfully limitated
- Collateral ligaments → Valgus- and Varusstress or collapsibility
- Patella → position, (sub-)luxationes
- Menisci → e.g. Steinmann I & II., Payr-sign, Apley-sign, McMurray-sign
- ACL and PCL → Lachman-test and Drawer-test, KT1000® (all translation), Pivot-shift-test (rotation)

During the clinical examination it is obligate to bring the patient into a relaxed position to achieve unbiased results because of the patients` muscle tension. This is an aspect that makes inexperienced examiners fail in appropriate diagnosing.
Mean of first choice is the Lachman-test (performed in 25° of flexion), followed by the Drawer-test (performed in 70 or 90° of flexion).

An ACL rupture is almost presumably when Lachman, Drawer-Test and /or KT1000® are positive, which means that there is either no noticeable stop while pulling or a remarkable difference of more than 1cm.

The pivot-shift-test should not be performed in acute cases because of effusion and muscle tension. Therefore, it is an appropriate mean of examination in chronic cases.

A positive pivot-shift test is rated as an indication to surgery as well as concomitant lesions of other ligaments that inflict stability.

Valgus- and Varus-stress regarding pain experiences and collapsible knee should be performed.

Involvements of bone parts must be excluded by taking X-rays in 2 plains (anterior-posterior and lateral) because that would entail other treatment.
Especially preadolescents are prone to avulsions but adolescents should not be forgotten either regarding bone damage.

The clinical diagnosis must be verified by **m**agnetic **r**adiographic **i**mages (MRI) in the next step.

Via MRI verified ACL rupture and subjective feelings such as “giving-way attacks”, a blocking knee, in general subjective discomfort and positive pivot-shift are subjects to act almost immediately.

Surgeon and patient should take techniques and aftertreatment behaviour in regard to ensure best individual profit for the patient.

4.5 *ACL reconstruction "all-inside" in "outside-in" - technique*

This is an ALC reconstruction using a single bundle hamstring, to be more exact the semitendinosus tendon. This allograft is inserted through retrograde drilled femoral and tibial sockets whereby this drilling happens by using the "all-inside" technique. This means that everything (in common: entering, debriding, drilling the tibial sockets and chucking) happens via arthroscopic portals whereby the femoral socket is drilled in "outside-in" – technique (from the lateral outside towards the center of the tibiofemoral joint) while observation again through the anteromedial arthroscopic portals.

4.5.1 Common arrangement

- Bringing the patient in supine position for classic knee arthroscopy.
- Anaesthesia.
- Conscientious lavation, covering and disinfection of the intervention area.
- Prophylactic antibiosis.

4.5.2 From diagnosis to surgery

After diagnosis all patients have to undergo MRI to verify the ACL rupture or other lesions in the knee. Regarding the patients` age, sports activity level and clinical objective outcome, in common the urge of intervention, the time between diagnosis and surgery differs from patient to patient.

Youngsters and competitive sportsmen are predestinated to achieve surgical intervention earlier because there is an obligate need to restore physiological conditions to return to sports and to avoid secondary morbidities such as slicking and chondropathy in first terms.

All the other patients are advised to strengthen the thigh´s muscles by physiotherapy first because that can suffice to increase knee stability which means that intervention may not be necessary. Just in cases of "giving way attacks", impingement and all therefore associated personal discomfort in daily routine a

surgical intervention should be discussed after the trial of this conservative treatment. This is why the time between diagnosis and surgery seems to be prolonged.
Regarding concomitant of other ligamental lesions, such as meniscal rupture, pathologies were surgical treated in one surgery. This is why, regarding financial and social aspects, this procedure decreases intramural stay and let patients return to daily routine earlier.

4.5.3 Harvesting of the semitendinosus-autograft

Under extension of the knee an about 1,5cm long incision is done posteromedial barely superior of the flexion fold and the muscular fascia is split. Regarding the "classic" withdrawal in "all-inside"-technique that pretends an incision at the Condylus medialis tibiae to overview the Pes anserinus superficialis, this technique has its advantage in shortening the withdrawal time, better cosmetic outcome and no irritation of the saphenus nerve. Moreover this procedure profits of decreased infectious risk. The tendon of the Musculus semitendinosus is hooked and traced all the way and cut via tendon-stripper first at the proximal and then at the distal end.
Prior goal is to obtain a material with a total length of about 24cm with fringed ends already cut off.
In case of insufficiency of the autograft (a diameter of at least 7-8mm should be obtained) the tendon of the Musculus gracilis can be also harvested here if necessary.

4.5.4 Preparation of the graft

The tendon is going to be debrided from muscle and quadrupled to a bunch with a total length of 6,5 to 7cm. One must estimate if additional Gracilis-tendon withdrawal is now necessary or if the autograft is thick enough to ensure stability.
The diameter measurement is also obligate to be able to choose the right calliper of the FlipCutter (Arthrex Inc.) to drill the sockets.
The ends of the tendon are sutured, the graft is quadrupled and the TightRopes (Arthrex Inc.) are arranged for further fixation on the tibia and femur. The graft is

straightened, so that the sutured end is positioned as a nod under the tendon-material. The nod is oriented at the end of the bunch and, after augmentation of the ends of the graft by sutures, it now appears as the so called “buried nod”.
Both ends are marked by sutures at a distance of about 1,5-2cm from the ends to have better notice the right length of the intra-articular segment while intraoperative positioning of the graft in its tunnels.
The graft is now tensioned at 40N for a few minutes and finally covered in damp gaze while preparation of the tunnels to decrease the risk of slicking of the graft.

Figure3: tension and diameter

Source: http://www.ortho-praxis.ch/kreuzband-en.php

4.5.5 Preparation of the tibial roof and the femoral notch

Referred to the standard diagnostic knee arthroscopy incisions for the anteromedial and anterolateral portals in 90° of flexion must be done, to enter the joint in front of the “Hoffa-body” (Corpus adiposum infrapatellare).
First to happen is to maintain a panoramic view. Medial and lateral compartment are both examined, the menisci are checked regarding their stability via a small hook. At this time, in case of laceration or rupture of the menisci, a suture can be set or a resection can be performed.
The former place where the ACL used to run is now seen as the “empty-wall”, whereas parts of the Hoffa-body are off which explains pain experiences because the roll-and-float-mechanism is afflicted.
Next to do is to examine the origin and the insertion of the ACL, here to be more exact the tibial roof, and the femoral notch as the anatomic insertion sites. These footprints are debrided from ligamental remnants. Regarding this shaving one has

to be cautious not to hit or shave other ligamental structures, such as the Ligamentum obliquus transversum.

The femoral notch itself should be debrided over the whole length of the medial site of the Condylus lateralis for better view to take the state of the osteochondral border, to be more exact perfusion and surface condition, in account.
After that one is able to measure the distances that must be kept when drilling the femoral tunnel. To be more exact the designated tunnel should be placed in a position at about 40% of the distance from the back wall or about 60% of the distance from the front wall of the lateral condyle, “located about halfway between the posterior fossa of the lateral intercondylar ridge” (20) and the lateral bifurcate ridge is marked with a microfracture awl.
To view the portal areas a 30° arthroscope is used.

4.5.6 Drilling the sockets

Now it comes to decide whether to screw transtibial or in outside-in technique.
The advantage of the outside-in-technique is seen in, apart of higher costs (2), having more latitude regarding the flexion while drilling, in decreasing cartilaginous and bone damage and in having almost physiological conditions regarding inlet and steepness of the graft. Moreover a study performed by Seo et al. (22) claim superior rotational stability in the knee after this kind of surgery.

Still in 90° of flexion the Femoral Guide (Arthrex, Inc.) is placed at about 110° that allows outside-in guide pin. Next to happen is the retrograde drilling via the FlipCutter (Arthrex Inc.). Its diameter should be first 1mm less than the before measured diameter of the graft which determines the final diameter of the FlipCutter because the graft should be in total contact with the bone tunnels to avoid widening of the tunnels and abrasion of the graft. A 20 or 25 mm deep socket is performed whereby the last 5mm are drilled via the integrated stepped Drill sleeve to spare the corticalis from harm.
Entry point of the tibial tunnel is placed anterosuperior to the junction of the medial collateral ligament and Pes anserinus.

Using the Tibial Guide (Arthrex, Inc.) it comes again to drilling at an angle of 45 – 60° towards the Eminentia intercondylaris.

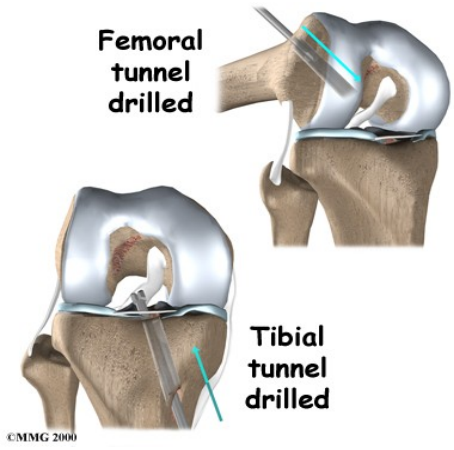

figure 4 – femoral and tibial tunnels

source: http://www.eorthopod.com/content/hamstring-tendon-graft-reconstruction-acl

4.5.7 Chuck and tight

Guide wires are placed that help chuck the TightRopes and thus chuck the graft from tibial to femoral side.

The graft is placed till the marked ends of the graft enter the bone apertures. That ensures the right intra- and extra-articular segments of the graft.

Subsequently knee is straightened to 15 - 30° of flexion to check possible impingement adjunct to a total knee extension.

Finally the graft is tightened referred to the whip and derry mechanism in both tunnels. It is fixed via the EndoButtons (Arthrex Inc.) at the Tightropes at both tibial and femoral sides.

A Redon´s suction drainage is placed before final suturing and dressing.

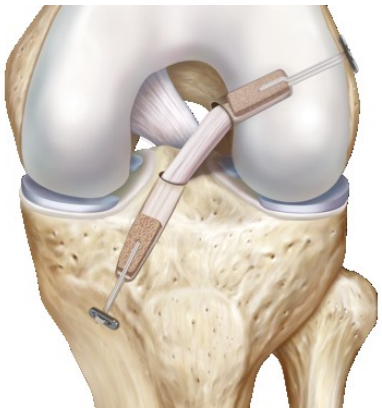

Figure5 – positioned graft

source: https://www.arthrex.com/knee/acl-btb-graft-fixation

4.6 *Post intervention time*

Prior goal is to achieve analgesia and to practise thrombosis prevention, cryotherapy and to regain full ROM as soon as possible.

Postinterventional full load is predetermined, to achieve a more exact full range of motion after isolated ACL tears.

Another prior goal is to increase strength of the thighs to better stabilize the knee.

Sports activities that are prone to ACL-injuries, in common cutting / pivoting activities, are advised to be performed not earlier than 12 months. Certain isokinethic tests are advised before the return to these sports activities. An almost equal circumference of the thigh compared to the non-injured side is also significant when it comes to monitor the muscle strength regarding the return to these sports activities.

For further information see the aftertreatment sheet below in chapter 12.

Benea et al. (1) concluded in their study that using the “all-inside”-technique the postoperative pain level at one month seemed to be decreased in comparison to other “classic” techniques while the analgetic consumption seemed to be equal. “The all-inside technique is a reliable procedure with very good results for pain, stability and knee function”.

Regarding rerupture and ACL rupture of the contralateral side Webster et al. performed a case-control-study to identify long-term effects that seemed to reveal that patients, younger than 20 years of age, were more likely to have an increased

risk to both mentioned injuries (7). These results depend also from the fact that younger patients are more likely to return to sports than elderly (8).

5 Materials and Methods

5.1 *Study*

A monocentric retrospective study, including a cohort of 48 patients, was performed. All these patients had their surgery at least 1 year or more before summoning to ensure the stability site of the knee while examination after reconstruction “all-inside”.

Drop-out criteria were re-rupture of the graft, lesions of other ligaments in the same knee, pregnancy, breast-feeding women, minors and men and women with fixed magnetisable implants in their body.

To collect data, a clinical examination and MRIs of both knees were performed.

All data were blinded by codes so that data are subsequently indirectly individual-related.

5.2 *Tests and Diagnostics*

All the patients had just one surgeon, just one independent examiner (neither financial interest nor connections to a company) and just one external radiologist (blinded and again neither financial interest nor connections to a company) which means that there was no bias to consider in each practise.

The patients were asked to participate in this study per mail. While the interview every patient was again precisely informed about the study in common, the examination and the MRI, all possible risks included. They all signed consent.

Furthermore they surely had the chance to discuss certain problems regarding their present personal contentment with their physical constitution.

5.2.1 IKDC objective

The objective International Knee Documentation Committee Test includes common examinations regarding the stability of the knee.

As a variance we used the KT1000® (explanation below) and Lachman at maximum strength to visualize possible differences in translation of the tibia.

We forwent examinations regarding general laxity, alignment and position, subluxation and dislocation of the patella because that did not seem to be necessary in our study.
See the appendix below for more details.

5.2.2 **KT1000®** (MEDmetric, Corporation, San Diego, Calif)

In addition to the Lachman-Test and the Drawer-Test we used an instrument called the KT1000 arthrometer to determine an exact statement regarding the translation. It is a very reliable instrument in orthopaedic history when it comes to quick measurements.

Transaction of measurement (Source: http://www.medmetric.com/kt1.htm)

- Bringing the patient into a relaxed position.
- Positioning of an adjustable thigh support platform (20-35°).
- Positioning of the feet in the foot support platform to orient tibia.
- Fasten the autocleavable thigh strap to stabilize external rotation of tibia and which helps to keep the patient in a relaxed position.
- Search and mark the joint.
- Positioning of the arthrometer on the Patella while the mark on the arthrometer comes up to the marked joint → fixation.
- Calibration via pushing the force handle and adjusting the Zero-Position.
- Pull the force handle that evokes audible force level indicators (at 15, 20 and 30 lb.) whereby the 3rd tone is equitable to 134N (which represents the requested force in our case comparable to Lachman max.).
- Repeat the measurement (the average is listed).
- Transaction performed on the other side.

Figure 6 – KT1000 arthrometer®

source: http://www.genourob.com/de/arthrometer.html

5.2.3 Subjective IKDC score

The subjective IKDC Test gives information of the patient´s personal comfort or discomfort regarding stability of the knee in activities of daily living, possibility of burden in sports activities and characterization of pain.

Data were denoted in percentage via evaluation. 100% is the best result to achieve.

Endured complications were classified according to Goslings and Gouma.

5.2.4 WOMAC score (26)

The Western Ontario and McMaster Universities Arthritis Index considers daily activities in percentage. To be more exact it is a self-assessed test specific for osteoarthritis in hip and knee that includes 17 items regarding pain, stiffness and function in daily routine. Regarding these items Whitehouse et al. (27) claim that a reduced scale of these items (7 out of 17) seem sufficient and equal to the full scale. However 100% is the best result to achieve.

5.2.5 Tegner-activity-score (25)

The Tegner-activity-score that is also self-assessed by patients gives information of activity in sports, burden at work and in daily routine. So activity level before the injury can be compared with the activity level at present state. The scale includes notes from 0 to 10 whereby 10 is the best result to achieve.

5.2.6 Evaluation of the answer sheets

Before the interview all tests were each adapted to our study as followed and translated into German by myself.

The **objective IKDC score** was analysed as followed (see below). We went without the harvest site of pathology and the X-rays findings because regarding our study these subjects were not necessary.
Data were analyzed as explained below (chapter 11.1) and listed in an excel-database.

The **subjective IKDC score** was analysed via following internet-address: http://www.orthopaedicscore.com/scorepages/international_knee_documentation_comitee.html
Data were visualised in percentage and listed in an excel-database.

The **WOMAC score** was analysed via following internet-address: http://www.orthopaedicscore.com/scorepages/knee_injury_osteopaedic_outcome_score_womac.html
Data were visualised in percentage and listed in an excel-database.

The data of the **Tegner-activity-score** were simply transferred into an excel-database.

5.2.7 Statistics

75 eligible patients were informed per mail whereby 7 times address was unknown, 4 patients were unwilling to participate, 1 was too young and 15 could not be contacted by phone either. 48 patients agreed with the study.
43 MRIs were performed and assessed. The cohort was divided into 2 groups whereby the allocation was dependant on the steepness of the graft-angle. Angles <47° were allocated to group 1 while angles >47° were allocated to group 2 .

To find relations between graft-angle and clinical outcome, by using the pivot-shift-test, a two-tailed student t-test was performed whereby a $p \leq 0.05$ is set as significant (statistical evaluation via excel 2007).

Scores	Group 1	Group 2
IKDCs	86,2% (SD±9,5)	86,7 (SD±12,0)
IKDCo	1,9 (SD±0,8)	1,86 (SD±0,53)
Tegner before injury	6,3 (SD±1,8)	7,14 (SD±1,7)
Tegner ≥1a	5,4 (SD±1,7)	5,9 (SD±1,4)
WOMAC	95,1% (SD±5,4)	95,0 (SD±6,0)

Table1: mean value and standard deviation of several scores

Between these 2 groups no significant difference (p=0.99) could be found regarding the common clinical outcome (IKDC + Tegner + WOMAC).

Angles	Group 1	Group 2
Graft	39,7° (SD±5,7)	51,6 (SD±3,1)
ACL	51,2° (SD±6,2)	53,1 (SD±6,5)
Δ graft - ACL	-10,8 (SD±9,0)	-1,5 (SD±7,2)
Δ graft – 47°	-7,3 (SD±5,7)	4,6 (SD±3,1)
PCL ipsilateral	100,3° (SD±10,9)	104,6 (SD±16,3)
ΔPCL ipsi-:contralateral	-19,9° (SD±13,0)	-7,4 (SD±12,0)

Table 2: mean value and standard deviation of angles

Obvious was that group 1 had a larger femoral tunnel (graft) angle (39,7° ± 5,7°) and a smaller inclination angle (ACL) (51,2° ± 6,2°) while group 2 had in mean an almost physiological placed femoral tunnel (51,6° ± 3,1°) compared to their inclination angle (53,1 ± 6,5). Similar constellation could be found in the PCL angles ipsi- and contralateral.

	IKDCs	IKDCo	KT1000	pivot	Δangles	PCL
ρ	0,899	0,906	0,52	0,674	0,002	0,298

Table3: ρ scores (significance) between group1 and group2

The difference between the graft- and the inclination angle was significant (ρ=0,002).

All other aspects had no relevant significant by comparison these two groups.

5.2.8 Magnetic Resonance Imaging (MRI)

The team of the Department of Radiology at the UKH Linz performed T1- and T2-weighted images as requested by an external board certified radiologist with fellowship-equivalent training in musculoskeletal radiology and 8 years of MRI experience who finally analysed all images.

Regarding the MRI assessment of the knee we assessed the WORMS score and performed angle-measurements of the graft-, ACL- and PCL of both knees.

The measurements as given above were performed twice in an interval of 2 weeks to determine the intraobserver error.

Intraobserver error reliability was high with small errors of measurement.

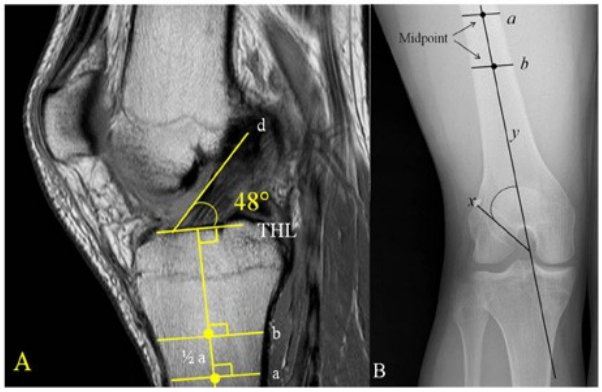

Figure7: inclination angle (a) and femoral tunnel angle (b)

Source: http://www.aaosnotice.org/2012_Proceedings/papers-SportsMedicine.html

Evaluation of the MRIs was done with an OsiriX MD 2.8.2 (Pixmeo SARL, Bernex, Switzerland) Apple Mac Workstation (Apple Inc., Cupertino/CA, USA).

5.2.8.1 MRI protocol

The MRI protocol is similar to the recommended Knee MRI protocol of the European Society of Skeletal Radiology (ESSR) - Sports Section:

(https://www.sybermedica.com/pm/index.php?option=com_content&view=article&id=280)

Axial	Parallel to knee joint line. Includes: whole patella down to fibula head
Coronal	Axial slice - along posterior aspects of the femoral condyles. Includes: posterior aspect of patella to 2cm behind femoral condyles.
Sagittal-oblique	Axial slice – medial aspect of lateral condyle (~almost line of ACL). Includes: both collateral ligaments.

Table 4: Scan Planes (slice guideline parallel to ACL; kindly provided by courtesy of Georg Scheurecker)

5.2.8.2 WORMS-schema

The **W**hole-**or**gan **m**agnetic resonance imaging **s**core assesses damage(s) of the knee joint, whereby each compartment is analysed regarding all factors (in common 14 features are assessed, e.g. subarticular bone marrow oedema, bone and cartilage surface, cysts, bursae, menisci etc.).
The ACL is simply assessed as intact or torn.

6 Results

48 patients (17 women and 31 men) at mean age of 35years (SD±12) underwent a clinical examination. 43 patients had MRIs of both knees done. 8 patients dropped out whereby 5 because of re-rupture, 1 because of rupture of another ligament and 2 failed to complete the procedure. Mean interval from injury to surgery was 390,5 days (SD±1041), mean intervention time was 85,8min. (SD±13,2), mean stationary stay lasted 5,8 days (SD±1,4) and mean ambulant treatment lasted 201 days (SD±93,6).

Common evaluation of the scores regarding the clinical outcome:
Between these 2 groups no significant difference (p=0.99) could be found regarding the common clinical outcome (IKDCs (85,16 ± 11,13%); IKDCo (1,93 ± 0,77), Tegner before injury (6,56 ± 1,76), Tegner ≥1a (5,51 ± 1,61), WOMAC (94,9 ± 5,24%)).
Regarding IKDCs (ρ=0,899) no significant difference could be found.
Regarding IKDCo (ρ= 0,906) no significant difference could be found.
Regarding KT1000® (ρ=0,520) no significant difference could be found.
Regarding pivot-shift-test (ρ=0,674) no significant difference could be found.
Regarding PCL (ρ=0,298) no significant difference could be found.
Regarding the difference between graft and inclination angle (ρ=0,002) a significant difference could be found.
Regarding the difference between the PCL angles (ρ=0,003) a significant difference could be found.

6.1 *Primary hypothesis*

There is a correlation between the graft-angle and the clinical outcome, measured by the IKDC score.

This hypothesis could be refuted. There is no correlation between the graft-angle and the clinical outcome (IKDC score).

6.2 *Secondary hypothesis*

There is a correlation between the graft-angle and stability, measured by the KT1000 and pivot-shift-test.

The hypothesis could be refuted. There is no correlation between the graft-angle and stability, measured by the KT1000 and the pivot-shift-test.

7 Discussion

The aim of this study was to evaluate the impact of the graft angle after ACL reconstruction in the “all-inside” technique on the clinical outcome, measured by clinical scores (IKDC, Tegner, WOMAC), and on stability, measured by the pivot-shift-test and KT1000®.

The hypothesis was that the graft angle would significantly influence this measured outcome. We found, that the clinical outcome and stability was however not influenced by the measured graft angle.

Various study groups (33, 34) have tried to find objective parameters, which might influence the clinical outcome and stability or laxity after ACL reconstruction.

Our hypothesis, that the graft angle would significantly influence the outcome could not be verified. According to previous investigations, we therefore believe, that the anatomic reconstruction is the major parameter influencing adequate outcome after ACL reconstruction (33, 36). In case of an anatomic reconstruction, the graft angle might differ between different knee joints because of the different relation between depths and widths (34).

Detailed analyses of our data show that in group 1 a mean graft angle of 38,9 $\pm$ 6,4° whereas in group 2 a mean graft angle of 51,6 $\pm$ 3,1° could be measured. Similar angle constellations can be found in the study performed by Seo et al. (22).

Regarding the clinical outcome after ACL-reconstruction results could be found that were similar to other studies (29, 33, 35).

The “all-inside” technique seems to be in advantage in lower postinterventional pain experience (1, 29), in decreasing infectious risk and interventional cartilaginous and bone damage.
Moreover advantages are also seen in having more latitude while intervention and by performing the press-fit technique secondary morbidities seem to be decreased as well (35). In addition there seems to be a better rotational stability after this kind of reconstruction (22) while Angoules et al. (38) reported on improved anterior-posterior stability although results seemed to be better after BPTB reconstruction.

Zhu et al. (39) declared the single-bundle and the double-bundle techniques as equal when it comes to clinical outcome (whereby IKDC score was significantly higher in the double-bundle group) and tibial translation.

However, so far no long-term-effects are examined.

Considering the aspect of withdrawing just one tendon (M. semitendinosus) no significant differences regarding laxity could be found in comparison to the ST/G technique whereby the gracilis tendon is used in addition (37).

Nevertheless anatomic conditions regarding ACL volume and notch geometry and common conditions such as sex and weight (17, 19, 20, 23) must be considered before choosing the surgical technique because there seem to be differences in the outcome, complication rate and second morbidities according to each technique.

Beside 3 (before examination) verified re-ruptures while ambulant treatment (grade 2 according to Goslings and Gouma) only temporary complications (grade 1 according to Goslings and Gouma) became evident while stationary stay. That is a matter of 1 endured infect that was successfully antibiotically treated and moreover 4 knee joint punctures and 1 lancing of a blood blister were performed.

By performing the study-associated MRIs 2 other re-ruptures and 1 lesion of another ligament (grade 3 according to Goslings and Gouma) could be identified.

8 Limitations

At that moment the study was still underpowered (*n* is too low).
A further sizing regarding the graft angle could have revealed better results.
Another limitation could have been the fact that we did not differ between isolated ACL ruptures and those combined with other ligamental lesions although at the time of the follow-up there should not have been any difference regarding knee stability.
So far no long-terms-effects could have been examined.

9 Conclusion

Although the study was underpowered, results show that the steepness of the graft angle seems to have no influence on the clinical outcome at one year after ACL reconstruction. Regarding the stability of the knee joint no differences between the two groups could be found either.

10 Future

Regarding the subjective clinical outcome and angle-constellations I think that there will follow similar studies, associated to other techniques, to find diversities or links. That will help surgeons and patients to decide which technique would be best for each individual case.
Moreover the radiological aspect might not be underestimated. It would be able to analyse the best possible tunnel-position via footprints in the MRI before intervention. Inexperienced surgeons may profit from computer-assisted ACL reconstruction.

Regarding the surgical site we hope to have better insight to be able to contribute to steadily improving all interventional techniques.

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12 Curriculum vitae / Thalhammer Dagma

Persönliche Daten

Wohnort:	Weinberggasse 32; 7032 Sigless
Geburtsdatum / –ort:	16.12.1982, 7000 Eisenstadt
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Ausbildung

1989 – 1993	Volksschule Sigless
1993 – 2001	Bundesrealgymnasium Wiener Neustadt
2001 – 2004	Universität Wien
Seit 2004	Medizinische Universität Graz

Famulaturen / Praktika

Allgemeine Chirurgie:	Barmherzige Brüder Eisenstadt
	Landesklinikum Wiener Neustadt
	A. ö. Oberwart
	A. ö. Krankenhaus Oberpullendorf
Orthopädie:	Barmherzige Brüder Eisenstadt
Innere Medizin:	Landesklinikum Wiener Neustadt
	A. ö. Krankenhaus Oberpullendorf
Anästhesie:	Barmherzige Brüder Eisenstadt
Radioonkologie / Strahlentherapie:	Landesklinikum Wiener Neustadt
Onkologische Rehabilitation:	„Der Sonnberghof“ in Bad Sauerbrunn

Praktisches Jahr

Diagnostische und interventionelle Radiologie:	Klinikum Traunstein (D)
Urologie und Kinderurologie:	Klinikum Traunstein (D)
Innere Medizin mit Gastroenterologie:	Klinikum Immenstadt i. Allgäu (D)
Allgemeinmedizin:	Dr. Wanke-Jellinek, Bad Sauerbrunn

Fremdsprachen

Englisch - Wort und Schrift; Französisch – Grundkenntnisse

Bisherige berufliche Tätigkeiten

2000 – 2014	diverse Tätigkeiten, u.a. in der Gastronomie, Versicherungsanstalten, in Österreich
Seit 2004	Angestellte bei „Wagner - Sicherheit“, 7000 Eisenstadt
2005 – 2010	Angestellte in „Trafik Weiss“, 8010 Graz
2010 –2013	Kellnerin im „Restaurant, Bar, Café Rondo“, 8020 Graz

13 Appendix – project plan

Committment of diploma thesis (January 2013)

Literature research

Concept preparation

Application of permit → insurance

Application of permit → medical director/ AUVA

Submission of ethnic request (September 2013)

Audition to ethics commission

Recruitment of the patients → information per mail

Control of recruitment by phone

Clinical examination and evaluation of data

Fixing date of MRI

Performance of MRIs (till end of November 2013)

Teleradiological transfer of MRIs to OA. Dr. Georg Scheurecker for evaluation

Data transfer into excel database

Statistical evaluation of final data by Priv. Doz. Dr. Patrick

Finalization of diploma thesis

2nd stage of study to complete the study after submission of the diploma thesis

A publication is foreseen

14 Appendix – Answer sheets in German

14.1 *IKDC objektiv*

	Normal	Fast normal	Abnormal	Deutlich abnormal	Gruppengrad A B C D
Erguss	Kein	Leicht	Mäßig	Deutlich	
Passives Bewegungsdefizit					
Streckdefizit	<3°	3-5°	6-10°	>10°	
Beugedefizit	0-5°	6-15°	16-25°	>25°	
Ligamentuntersuchung					
Lachman Test (25° bei 134N)	-1-2mm	3-5mm	6-10mm	>10mm	
Hintere Schublade (70°)	0-2mm	3-5mm	6-10mm	>10mm	
Valgusstress	0-2mm	3-5mm	6-10mm	>10mm	
Varusstress	0-2mm	3-5mm	6-10mm	>10mm	
Aussenrotation (30°)	<5°	6-10°	11-19°	>20°	
Aussenrotation (90°)	<5°	6-10°	11-19°	>20°	
Pivot shift	gleich	+gleiten	++dumpf	+++laut	
Kompartmentbefund Krepitation anterior medial lateral	Kein	Mäßig	Leichter Schmerz	>leichter Schmerz	
Funktionstest	>/= 90%	89-76%	75-50%	<50%	

*Group grade: The lowest grade within a group determines the group grade

** Final evaluation: the worst group grade determines the final evaluation for acute and subacute patients. For chronic patients compare preoperative and

postoperative evaluations. In a final evaluation only the first 3 groups are evaluated but all groups must be documented.

∆ Difference in involved knee compared to normal or what is assumed to be normal

Source:

http://www.sportsmed.org/uploadedFiles/Content/Medical_Professionals/Research/Grants/IKDC_Forms/IKDC%202000%20-%20Revised%20Subjective%20Scoring.pdf

14.2 *IKDC subjektiv*

1. Was ist die **höchste Aktivitätsstufe**, die Sie **ohne erhebliche Schmerzen** im Knie ausüben können?

- o Sehr anstrengende Aktivitäten wie Springen oder Drehbewegungen bei einseitiger Fußbelastung (z.B. Basketball oder Fußball)
- o Anstrengende Aktivitäten wie schwere körperliche Arbeit, Skilaufen oder Tennis
- o Mäßig anstrengende Aktivitäten wie mäßige körperliche Arbeit, Laufen oder Joggen
- o Leichte Aktivitäten wie Gehen, Haus- oder Gartenarbeit
- o Ich kann aufgrund meiner Schmerzen im Knie keine der oben genannten Aktivitäten ausführen.

2. Wie oft hatten Sie in den vergangenen 4 Wochen oder seit dem Auftreten Ihrer Verletzung Schmerzen? **0 (Nie)** bis zu **10 (Immer)**.

0 1 2 3 4 5 6 7 8 9 10

3. Wie stark sind Ihre Schmerzen? **0 (keine)** bis **10 (unerträglich)**.

0 1 2 3 4 5 6 7 8 9 10

4. Wie **steif oder geschwollen** war Ihr Knie während der vergangenen 4 Wochen?

Überhaupt nicht	Etwas	Ziemlich	Sehr	extrem

5. Hatten Sie in den vergangenen 4 Wochen ein **gesperrtes Knie oder ist Ihr Knie aus- und wieder eingeschnappt**?

Ja	Nein

6. Was ist die **höchste Aktivitätsstufe**, die Sie **ohne erhebliches Anschwellen** des Knies ausüben können?

- o Sehr anstrengende Aktivitäten wie Springen oder Drehbewegungen bei einseitiger Fußbelastung (Basketball oder Fußball)
- o Anstrengende Aktivitäten wie schwere körperliche Arbeit, Skilaufen oder Tennis
- o Mäßig anstrengende Aktivitäten wie mäßige körperliche Arbeit, Laufen oder Joggen
- o Leichte Aktivitäten wie Gehen, Haus- oder Gartenarbeit
- o Ich kann aufgrund eines geschwollenen Knies keine der oben genannten Aktivitäten ausführen.

7. Was ist die **höchste Aktivitätsstufe**, die Sie **ohne erhebliche durch Knieschwäche verursachte Gangunsicherheit** einhalten können?

- o Sehr anstrengende Aktivitäten wie Springen oder Drehbewegungen bei einseitiger Fußbelastung (Basketball oder Fußball)
- o Anstrengende Aktivitäten wie schwere körperliche Arbeit, Skilaufen oder Tennis
- o Mäßig anstrengende Aktivitäten wie mäßige körperliche Arbeit, Laufen oder Joggen
- o Leichte Aktivitäten wie Gehen, Haus- oder Gartenarbeit

- o Ich kann aufgrund eines geschwollenen Knies keine der oben genannten Aktivitäten ausführen.

8. Was ist **die höchste Aktivitätsstufe**, an der Sie **regelmäßig teilnehmen** können?

- o Sehr anstrengende Aktivitäten wie Springen oder Drehbewegungen bei einseitiger Fußbelastung (Basketball oder Fußball)
- o Anstrengende Aktivitäten wie schwere körperliche Arbeit, Skilaufen oder Tennis
- o Mäßig anstrengende Aktivitäten wie mäßige körperliche Arbeit, Laufen oder Joggen
- o Leichte Aktivitäten wie Gehen, Haus- oder Gartenarbeit
- o Ich kann aufgrund eines geschwollenen Knies keine der oben genannten Aktivitäten ausführen

9. **Wie schwierig** sind aufgrund Ihres Knies die folgenden Aktivitäten für Sie?

	Überhaupt nicht schwierig	Minimal schwierig	Ziemlich schwierig	Extrem schwierig	unmöglich
Treppensteigen					
Treppen hinuntergehen					
Auf der Vorderseite des Knie knien					
Hockstellung					
Sitzen mit gebeugten Knien					
Vom Stuhl aufstehen					
Geradeauslaufen					
Hochspringen und auf dem betroffenen Bein landen					
Beim Gehen/Laufen schnell anhalten und starten					

FUNKTION:

10. Wie würden Sie die Funktionsfähigkeit Ihres Knies auf einer Skala von 0 bis 10 beurteilen**? 0 (kann keine täglichen Aktivitäten**, darunter möglicherweise auch Sport, auszuführen) und **10 (normale und ausgezeichnete Funktionsfähigkeit**)

Funktionsfähigkeit ihres Knies **VOR** dem Unfall: (wird nicht gewertet)

0 1 2 3 4 5 6 7 8 9 10

DERZEITIGE Funktionsfähigkeit:

0 1 2 3 4 5 6 7 8 9 10

14.2.1 Schweregrad – Einteilung nach Goslings und Gouma

Aufgetretene Komplikationen werden gemäß Goslings und Gouma klassifiziert. Es werden hierfür Komplikationen, die stationär und ambulant auftreten, separat notiert.

Grad 1	temporäre Beeinträchtigung
Grad 2	Genesung nach Revision
Grad 3	möglicherweise permanenter Schaden
Grad 4	Tod
Grad 5	vorzeitiger Tod unklaren Ursprungs

Table 5: Komplikationsklassifikation nach Goslings und Gouma (14)

14.3 *Tegner- score*

Jetzt			vorher
	Hochleistungssport – nationale und internationale Elite	Fußball	
	Leistungssport	Eishockey, Ringen, Turnen, Fußball (untere Ligen)	
	Leistungssport	Skifahren, Badminton, Squash, Leichtathletik (Weitsprung)	
	Leistungssport Freizeitsport	Handball, Tennis, Basketball, Leichtathletik (laufen), Querfeldeinlauf Eishockey, Fußball, Squash, Weitsprung, Querfeldeinlauf	
	Freizeitsport	Badminton, Tennis, Basketball, Skifahren, Joggen bis 5x/ Woche	
	Leistungssport Freizeitsport Arbeit	Radfahren, Skilanglauf Joggen auf unebenem Boden mind. 2x/Woche Schwerarbeit (Bauarbeiter)	
	Freizeitsport Arbeit	Skilanglauf, Radfahren, Joggen auf ebenem Boden mind. 2x/Woche zeitweise schwere Arbeit	
	Leistungssport Freizeitsport Arbeit Gehen	Schwimmen Schwimmen leichte körperliche Arbeiten Gehen auf unebenem Boden	
	Arbeit Gehen	kaum körperliche Arbeit Gehen im Waldunmöglich	
	Arbeit Gehen	überwiegend sitzend Gehen nur auf ebenem Boden möglich	
	Arbeit Gehen	Arbeitsunfähigkeit Wegen Kniegelenksverletzung normales Gehen nicht möglich	

14.4 *WOMAC score*

Funktion /Schwierigkeiten?	Nein	Leicht	Ziemlich	Stark	extrem
Treppe runter					
Treppe rauf					
Vom Sitzen aufstehen					
Stehen					
Zum Boden beugen/Etwas aufheben					
Auf ebener Fläche gehen					
In oder aus dem Auto steigen					
Einkaufen gehen					
Socken anziehen					
Vom Bett aufstehen					
Socken ausziehen					
Im Bett liegen (umdrehen während Knie an selber Stelle)					
Aus der / in die Badewanne steigen					
Sitzen					
Auf oder von der Toilette gehen					
Schwere Hausarbeit					
Leichte Hausarbeit					

15 Rehabilitation protocol (Nachbehandlungsschema)

OPERATEUR OP-DATUM

OPERATIONSTITEL

Liebe Patientin, lieber Patient!

Dieses Informationsblatt soll Sie über den Ablauf der Nachbehandlung informieren.

Änderungen sind aber jederzeit je nach Heilungsverlauf möglich.

Was geschieht in der 1. Woche:

1	Lagerung des Beines in Streckstellung
2	Schmerzlinderndes und abschwellendes Medikament
3	Thromboseprophylaxe mit Lovenox 40 mg Injektion 1 x täglich
4	Kältetherapie mit Eisbeutel
5	Bewegen der Vorfüße
6	Verbandwechsel und Entfernung des Drains (wenn vorhanden, nach ärztlicher Anordnung) und Anlegen eines Thrombosestrumpfes
7	Isometrische Spannungsübungen der Kniestrecker mit Physiotherapie auf der Station
8	Aktives Bewegen im schmerzfreien Bewegungsumfang mit voller Streckung im Kniegelenk
9	Belastung • ohne • Teilbelastung • Vollbelastung
10	Orthese (Genu Synchro 680)für 6 Wochen • keine • mit Einschränkung S: 0 -
11	Camoped Schiene S: 0-120 für 6 Wochen
12	Physiotherapie (Einzeltherapie und Lymphdrainage) unmittelbar postoperativ empfohlen

Was geschieht bei der Entlassung:

13	.Rezepte: Schmerz- und abschwellendes Medikament, Thromboseprophylaxe sowie Thrombosestrumpf • 3 Wochen • .6 Wochen
14	Mitgeben der Stützkrücken leihweise
15	Wiederbestelltermin beim Arzt 10.-14. Tag Nahtentfernung Nachbehandlung Kontrolle Knieambulanz 4.-6. Woche
16	Organisation der Physiotherapie

.

Was geschieht in der 2. bis 10. Woche:

17	Narbenmobilisation und Narbenpflege
18	Entwöhnung der Stützkrücken
19	Gangschulung, Training von Kraft, Koordination
20	Standfahrrad und Walker (Trainingsraum)

.

Maßnahme der 10. Woche bis 4. Monat:

21	Weiterführen der Übungen: 2 x 15 min/Tag
22	Radfahren, Krafttraining, Koordinationstraining

.

Ab dem 4. Monat:

Back to sport !

-> Beginn mit Lauftraining ab dem 4. Monat

-> Brustschwimmen ab dem 6. Monat

-> Isokinethiktest Sporttherapie Wels (Tel.: 07242/68700) empfohlen

Nach muskulären Wiederaufbau bzw. Isokinethiktest Rückkehr zum Sport nach 8 - 12 Monaten