

Graft choice:

QUAD, ITB, allograft



Prof Dr med Jacques Menetrey

*Centre de médecine de l'appareil locomoteur et du sport
Swiss Olympic medical Center*

Unité d'Orthopédie et Traumatologie du Sport (UOTS)

Service de chirurgie orthopédique et traumatologie de l'appareil moteur

*University Hospital of Geneva,
Geneva Switzerland*

Outline

- Epidemiology
- Generalities
- Quad tendon
- ITB
- Allograft

Epidemiology

- 1 ACL reconstruction/2000 inhabitants in US
- 200' 000 ACL reconstructions/year in US
- Direct cost \$ 3 billions
- 120' 000 TKR/year

Borphy et al *Am J Sports Med* 2009

- 31' 000 ACL reconstructions/year in France

Symposium *French Society of Arthroscopy* Paris 2008

- 3750-4000 ACL reconstructions/year in Switzerland

Graft choice

- Profile of the patient
- Surgeon's experience
- Isolated ACL vs multiple-ligaments injury
- Surgical and traumatic history

Graft choice

- Central third of the patellar tendon
- Hamstring tendons (DIDT)
- Central third of the Quad tendon
- Allograft (BPTB, Achilles, Hamstrings, TP, TA)
- ITB
- Synthetic graft

Graft choice

Graft type	Ultimate tensile load (N)
Original ACL	2160 (157)
Patellar tendon (10 mm)	2376 (151)
Semi-tendinosus (one strand)	1216 (50)
Hamstring (4 strands)	4108 (200)
Quad tendon (10mm)	2352 (495)

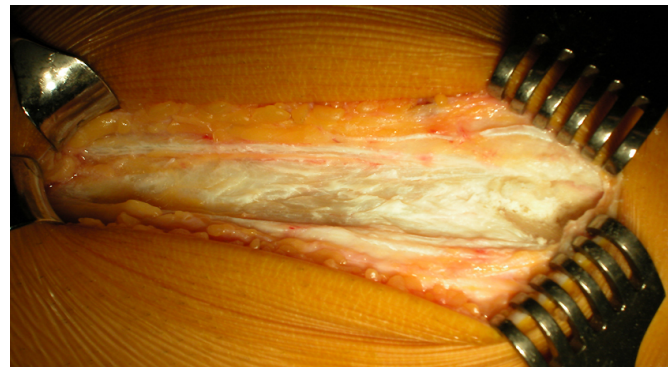
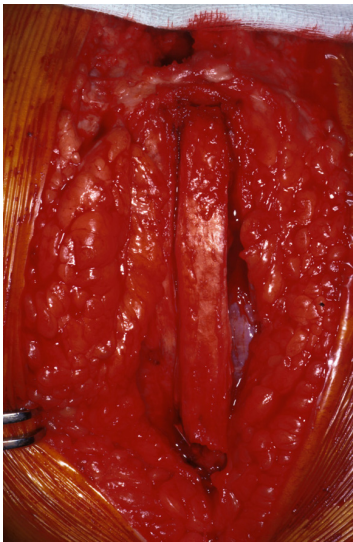
Well...



BREAK THE CODES*

Quadricipital tendon

- One bone plug
- 8 to 9mm (>11 mm) in diameter
- Ultimate tensile load: 2352 (495) N



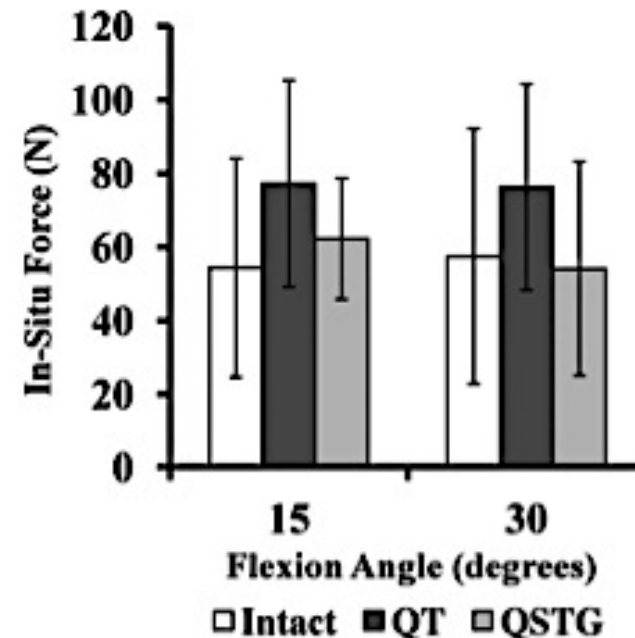
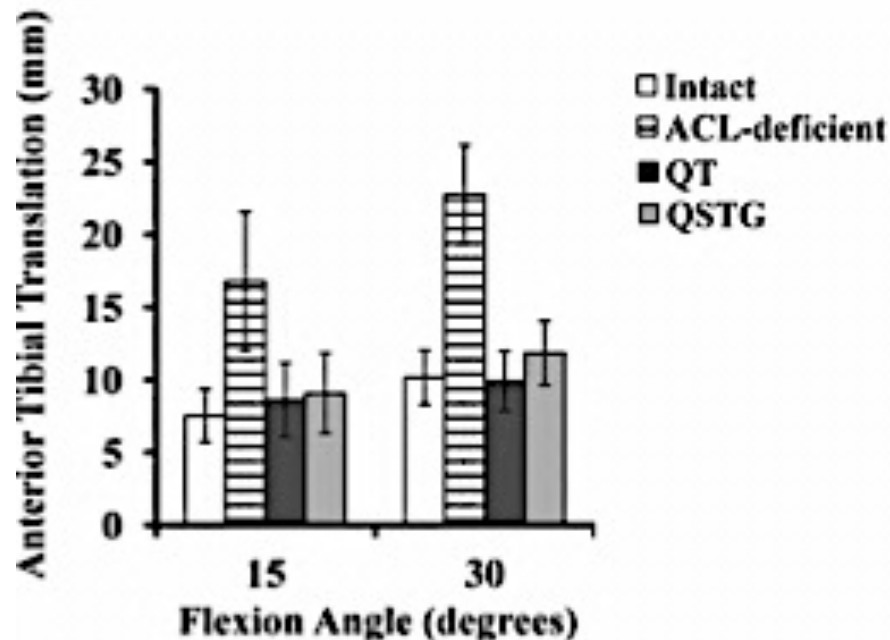
Quadricipital biomechanics

Biomechanical Evaluation of the Quadriceps Tendon Autograft for Anterior Cruciate Ligament Reconstruction

A Cadaveric Study

Norihiro Sasaki,* MD, Kathryn F. Farraro,* MS, Kwang E. Kim,* BS, and Savio L-Y. Woo,*[†] PhD, DSc (Hon), DEng (Hon)
Investigation performed at the University of Pittsburgh, Pittsburgh, Pennsylvania, USA

- n=10
- Compared QT to QSTG
- Robotic/Universal force moment sensor testing



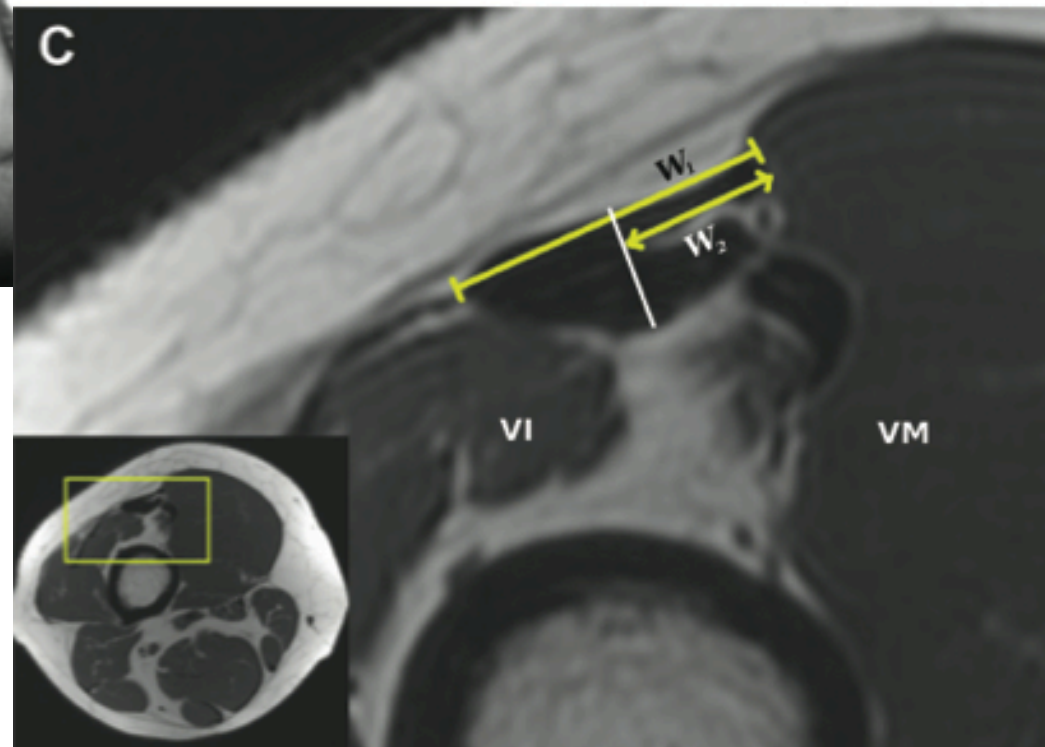
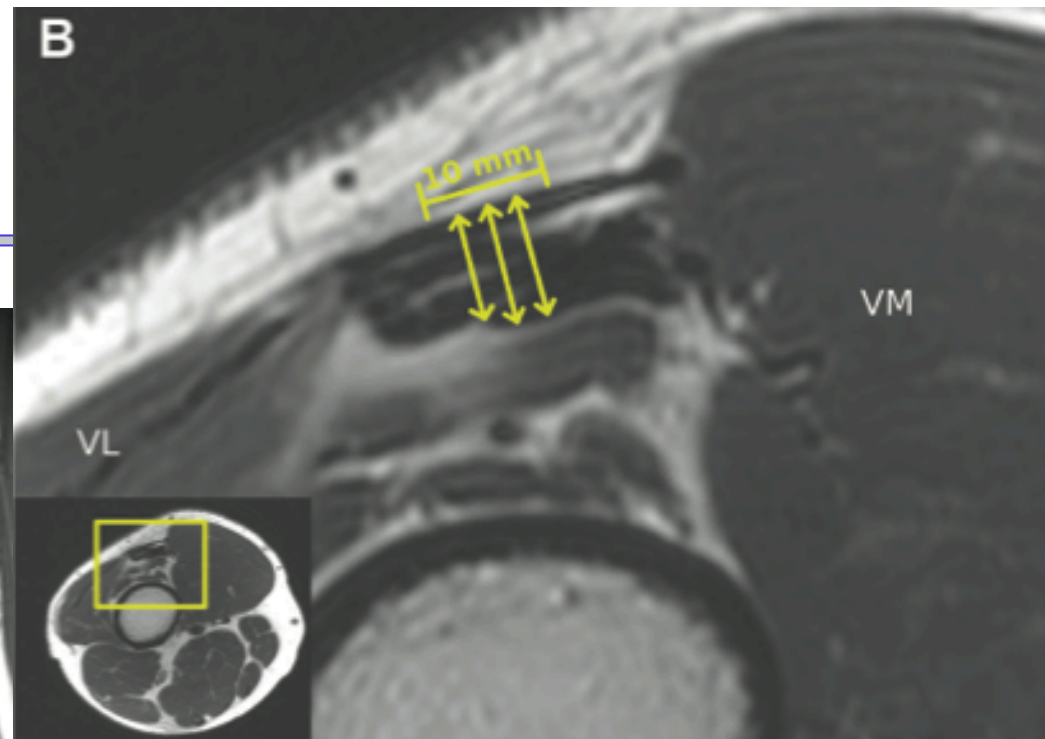
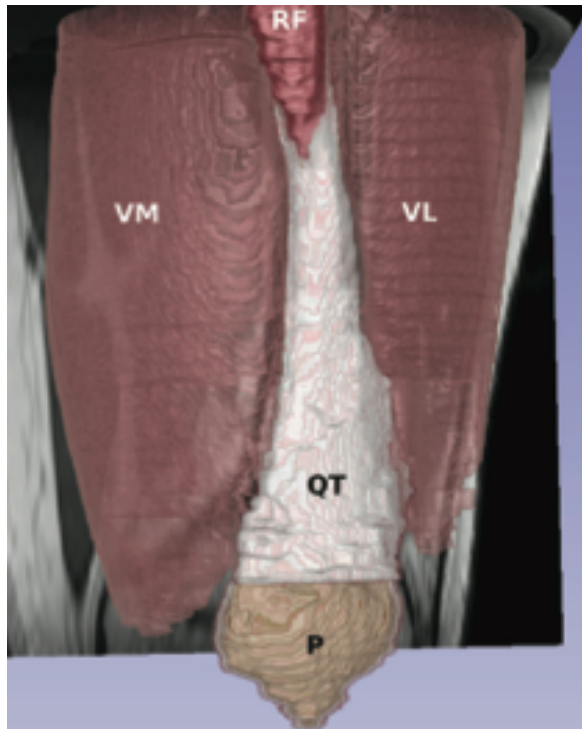
QUAD tendon +

- 1st choice in my practice
- Versatility - Customization of graft size
- Reduced anterior knee pain
- Reduced injury of the infra-patellar saphenous branch
- Don't touch ACL agonist
- Decrease arthrofibrosis compared to BPTB
- Better patellar mobility
- Reduced laxity with thicker graft

QUAD tendon -

- Technically more demanding
- Patella fracture
- More difficult to rehabilitate the QUAD
- Less anterior knee pain ?
- Weakness of the extensor apparatus ?

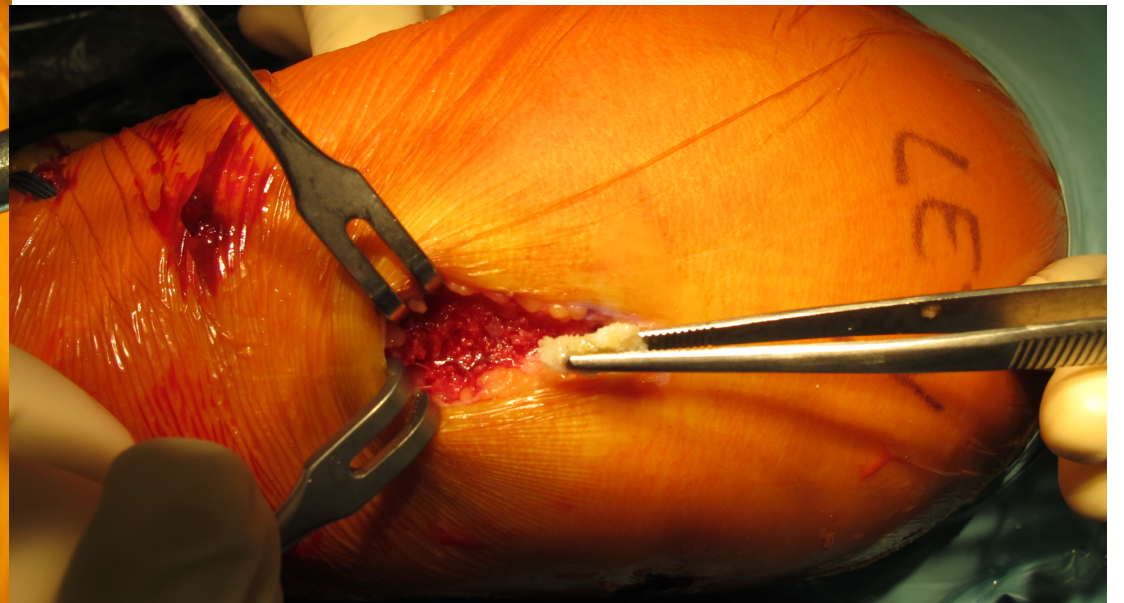
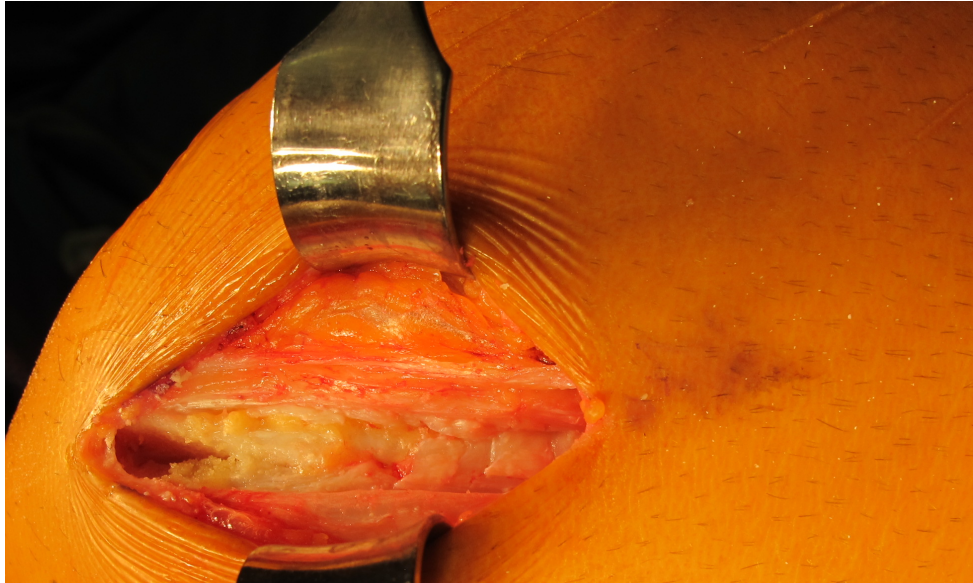
QUAD tendon



- Customized graft
- Intra-articular graft:
87% greater than BPTB

Xerogeanes et al *Am J Sports Med* 2013

Customized graft



QUAD tendon outcome

Anterior Cruciate Ligament Reconstruction: Autogenous Quadriceps Tendon-Bone Compared With Bone-Patellar Tendon-Bone Grafts at 2-Year Follow-up

Sung-Jae Kim, M.D., Praveen Kumar, M.S., and Kyung-Soo Oh, M.D.

Purpose: The purpose of this study was to evaluate and compare postoperative anterior knee pain, knee stability, and functional scores of an autogenous bone-patellar tendon-bone (BPTB) graft and a quadriceps tendon-bone (QTB) graft. **Methods:** A total of 48 patients—22 who had anterior cruciate ligament (ACL) reconstruction by use of an autogenous BPTB graft and 21 who had ACL reconstruction by use of a QTB graft—were assessed at a minimum follow-up of 24 months after surgery. An accelerated rehabilitation program was adopted, and the rehabilitation protocol was identical for both groups. **Results:** The mean side-to-side difference as measured with a KT-2000 arthrometer (MEDmetric, San Diego, CA) was 2.73 mm (SD, 1.45 mm) in the BPTB group and 2.79 mm (SD, 1.32 mm) in the QTB group ($P = .86$). Postoperatively, the International Knee Documentation Committee score was grade A or B in 23 patients (85.2%) in the BPTB group and 18 (85.7%) in the QTB group ($P = .99$). The mean anterior knee pain score was 46.4 in the BPTB group as compared with 46.2 in the QTB group ($P = .10$). In a kneeling posture, 13 BPTB patients reported discomfort (incidence in 19 use cases in 3), whereas only 4 QTB patients had moderate discomfort ($P = .02$). No significant differences were found with regard to other activities surveyed. **Conclusion:** A QTB graft treated with the final-foot device (Larus, Largo, FL) appears to be an effective alternative for single-bundle ACL reconstruction. When followed with an accelerated rehabilitation program, reconstruction with a QTB graft provided knee stability comparable to a BPTB graft but with less kneeling pain than a BPTB graft. **Level of Evidence:** Level III, retrospective comparative study. **Key Words:** Anterior cruciate ligament—Autogenous bone-patellar tendon-bone graft—Autogenous quadriceps tendon-bone graft—Anterior knee pain—Knee stability—Accelerated rehabilitation program.

Comparison of Single- and Double-Bundle Anterior Cruciate Ligament Reconstruction Using Quadriceps Tendon-Bone Autografts

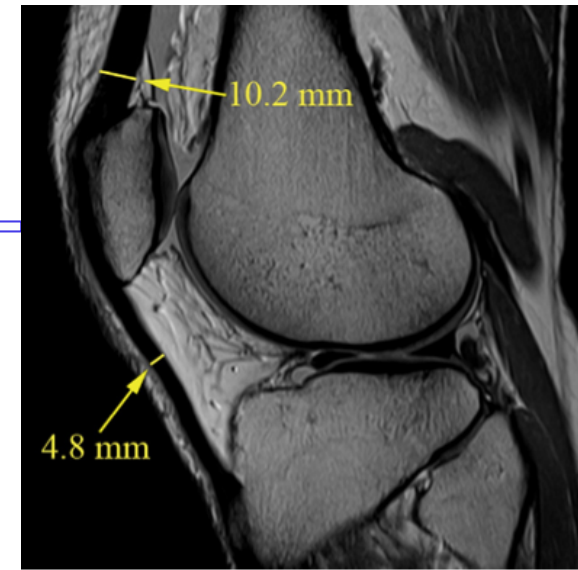
Sung-Jae Kim, M.D., Seung-Bae Jo, M.D., Praveen Kumar, M.S., and Kyung-Soo Oh, M.D.

Purpose: The purpose of this study was to evaluate and compare postoperative knee stability and functional scores between single- and double-bundle anterior cruciate ligament (ACL) reconstruction with the use of quadriceps tendon-bone autografts at a 2-year follow-up. **Methods:** The records of 59 patients who had ACL reconstruction between January 2005 and April 2006 were analyzed retrospectively. Twenty-eight patients had single-bundle reconstruction (group S) and 31 received double-bundle reconstruction (group D). Ligament stability was assessed with the Lachman and pivot-shift tests and a KT-2000 arthrometer. International Knee Documentation Committee (IKDC) and Lysholm scores were employed to evaluate the functional outcomes. **Results:** The postoperative mean side-to-side difference for group S was 2.64 mm and 1.79 mm for group D; a difference that was found to be statistically significant ($P = .02$). Regarding the pivot-shift test, 11 patients had grade 1+ and 1 patient had grade 2+ pivot-shift in group S, while no patients had abnormal pivot-shift in group D ($P = .29$). The patients who reported grade A or B on IKDC scores were 24 and 28 in group S and D, respectively ($P = .1$). On the questionnaire of the kneeling activity, although statistical difference was not found between the groups, there was a trend toward more restriction in kneeling activity in group S ($P = .06$). We found significant correlation between the kneeling activity and instability questionnaire of the Lysholm score (Spearman coefficient, 0.737; $P < .001$). **Conclusion:** Double-bundle ACL reconstruction using quadriceps tendon-bone autografts provided knee stability (1.79 mm) that single-bundle ACL reconstruction (2.64 mm) as measured by the KT-2000. However, we could not find any significant differences in the functional measurements of the 2 groups. **Level of Evidence:** Level III, retrospective comparative study. **Key Words:** Anterior cruciate ligament—Double-bundle reconstruction—Functional outcome—Knee stability—Quadriceps tendon-bone autograft.

Anterior Cruciate Ligament Reconstruction Using Quadriceps Tendon Autograft: Intermediate-Term Outcome

Timothy M. Geith, M.D., Walter R. Shelton, M.D., Raymond A. Phelps, D.B.A., and Lauren Clark

Purpose: The purpose of this study was to compare the intermediate-term outcomes of anterior cruciate ligament (ACL) reconstruction by use of bone-patellar tendon-bone (BPTB), quadriceps tendon with a bone plug (QT), and quadriceps tendon without a bone plug (QT). **Methods:** We evaluated 198 primary ACL reconstructions in 191 patients at a mean of 55.6 months postoperatively. Assessment included side-to-side comparisons of range of motion, arthrometer values, presence of effusion, anterior knee pain, and numbness. Comparisons were made between QT and BPTB results and between men and women. The results were compared with data from 39 patients in a previous study who had undergone ACL reconstruction by the same surgeon (W.R.S.) with BPTB. **Results:** Range of motion averaged $-3.3^{\circ} \pm 2.2^{\circ}$ of extension to $134.2^{\circ} \pm 10.1^{\circ}$ of flexion for the operative extremity compared with $-3.1^{\circ} \pm 2.07^{\circ}$ to $134.2^{\circ} \pm 10.0^{\circ}$ for the contralateral extremity at final follow-up. KT-1000 maximal maximum measurements (MEDmetric, San Diego, CA) with the operative extremity averaged 0.94 mm more than those of the normal contralateral knee. When compared with BPTB autograft, the quadriceps tendon autograft showed significantly better results, with less anterior knee pain (4.56% v 26.7%), less anterior numbness (1.5% v 53.3%), a higher percentage of arthrometer measurements showing a side-to-side difference of 0 to 3 mm (88% v 64%), and better extension (mean loss, 0.33° v 2.77°). There was no significant difference between the 2 groups with regard to loss of flexion, Lachman test, pivot-shift test, presence of effusion, or number of failures. **Conclusion:** Central quadriceps tendon autograft, QT or BPTB, produces equivalent results when compared directly with BPTB autograft in arthroscopically assisted ACL reconstruction. There was no difference in results between men and women with a quadriceps tendon autograft, either with or without the use of a bone plug. ACL reconstruction using quadriceps tendon autograft is an effective surgical option for the middle-aged athlete. **Level of Evidence:** Level IV, therapeutic case series. **Key Words:** Quadriceps tendon—ACL—BPTB—Bone Plug—Numbness—Anterior knee pain.



Numerous graft sources for anterior cruciate ligament (ACL) reconstruction have been introduced, including an autogenous bone-patellar tendon-

bone (BPTB) graft, a hamstring tendon graft, and allografts. The use of BPTB grafts in ACL reconstruction has been considered a standard procedure during the past decade, sometimes even called the gold standard. The BPTB graft provides rigid bone-to-bone fixation and quick bony healing, which allows accelerated rehabilitation to attain full range of motion (ROM) and muscle strength.^{1,2} On the contrary, it is often necessary with tendon grafts to delay mobilization, range-of-motion exercise, and physical therapy for protection of the weak link between the graft and bone tunnel.³ However, drawbacks associated with complaints at the harvest site, also referred to as donor-site morbidity, have been reported in up to 30% of cases.⁴ Meanwhile, an autogenous quadriceps tendon-bone (QTB) graft has been recommended as a

The anterior cruciate ligament (ACL) consists of 2 reciprocally functioning bundles: the anteromedial (AM) bundle is taut at flexion, and the posterolateral (PL) bundle is taut at extension.⁵ Single-bundle

(SB) ACL reconstruction reproduces the anatomy and kinematics of the AM bundle. Although conventional SB reconstruction generally provides satisfactory results, problems with rotational instability and long-term success of degenerative changes persist.^{6,7} Based on a biomechanical study, SB ACL reconstruction was found to be insufficient in controlling both anteroposterior (AP) translation and rotation in extension.^{8,9} Recently, double-bundle (DB) reconstruction was introduced to restore normal kinematics. In 2004, the senior author (S.-J.K.) developed a DB reconstruction procedure with 2 femoral sockets and 1 tibial tunnel with the use of quadriceps tendon-bone autografts.¹⁰ To date, several reports on DB reconstruction with 2 femoral sockets and 1 tibial tunnel using hamstring autografts have been published.¹¹

Anterior cruciate ligament (ACL) injuries occur with an annual incidence rate of 1 in 3,500 persons in the United States.^{1,2} It is estimated that over

100,000 ACL reconstructions are performed annually in the United States.³ The ACL-deficient knee can lead to recurrent instability, meniscus tears, and osteoarthritis. Levy and Meier⁴ noted that the incidence of meniscus tears in the ACL-injured knee is 40% at 1 year, 60% at 5 years, and 80% at 10 years. It has also been shown that radiographic changes consistent with osteoarthritis can be expected in up to 60% to 90% of patients 10 to 15 years after the index injury.⁵ Multiple graft options are available, each with its own unique advantages and disadvantages. The ideal graft should be capable of withstanding the translational and rotational stresses of the knee, allow for ingrowth in the bone tunnels, limit postoperative donor-site morbidity, and allow for early aggressive rehabilitation.

From the Department of Orthopaedic Surgery, Yonsei University Health System, Yonsei University, Anjungsri 4, Jamsil Research Institute, S.J.A., K.S.O., Seoul, South Korea, and Department of Orthopaedics, Loma Linda Hospital, L.A., South Korea. The authors report no conflict of interest. Received April 6, 2009; accepted September 2, 2009. Address correspondence and reprint requests to Kyung-Soo Oh, M.D., Department of Orthopaedic Surgery, Yonsei University College of Medicine, CPO Box 804, 134, Shinchon-Dong, Seodaemun-Ku, 120-752, Seoul, South Korea. E-mail: ortho@yuhs.ac.kr

From the Department of Orthopaedic Surgery, Yonsei University College of Medicine (S.-J.K., S.B.J., K.S.O.), Seoul, Korea, and the Department of Orthopaedics, Loma Linda Hospital (P.R.S.), South Korea. The authors report no conflict of interest. Received May 22, 2009; accepted September 2, 2009. Address correspondence and reprint requests to Kyung-Soo Oh, M.D., Department of Orthopaedic Surgery, Yonsei University College of Medicine, CPO Box 804, 134, Shinchon-Dong, Seodaemun-Ku, 120-752, Seoul, Korea. E-mail: ortho@yuhs.ac.kr

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Note: To access the supplemental video accompanying this paper, visit the December issue of Arthroscopy at www.arthroscopyjournal.org.

- Quad tendon produces clinical results similar to BPTB
- Less pain at kneeling
- Less donor site morbidity

Geib et al Arthroscopy 2009
Kim et al Arthroscopy 2009
Kim et al Arthroscopy 2009

Ilio-tibial band

- Mechanical properties close to original ACL (4.5 cm)

Noyes et al *Clin Orthop* 1983

- Fan-shaped ITB = tibialis ant allograft

Delcroix et al *Arthroscopy* 2013

- Good clinical results
- 20% cosmetic / 8% hernia complains
- Failure rate: 8.8%

Bak et al *KSSTA* 1999

Jorgensen et al *KSSTA* 2001

Ilio-tibial band

- Harvesting through two independent incisions
- n=60 patients ITB vs BPTB
- FU: 15 years
- No difference between both groups
- 16% vs 13% failure rate



Ilio-tibial band

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Reconstruction of anterior cruciate ligament deficient knees in soccer players with an iliotibial band autograft

A prospective study of 132 reconstructed knees followed for 4 (2-7) years

K. Bak¹, U. Jørgensen¹, J. Ekstrand², M. Scavenius²

Departments of Orthopaedic Surgery, Divisions of Sports Traumatology, ¹Gentofte Hospital, Denmark, and

²Linköping University Hospital, Linköping, Sweden

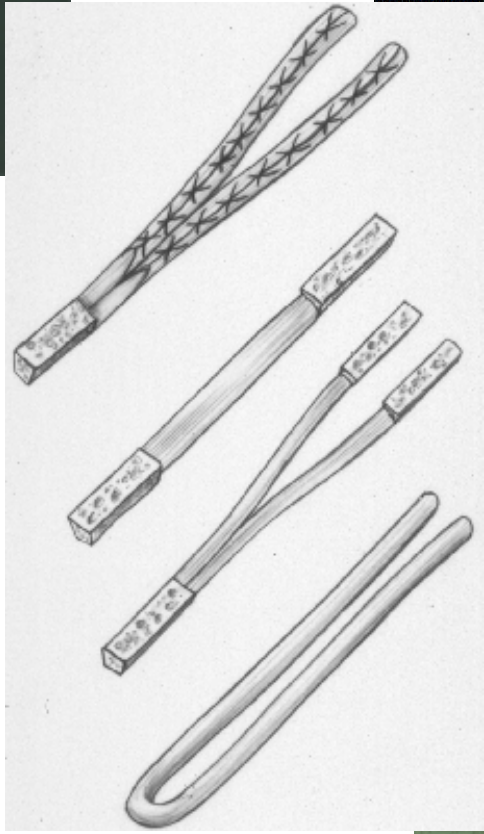
Corresponding author: Klaus Bak, Department of Orthopedics, Amager Hospital, Italiensvej 1, DK-2300 Copenhagen S, Denmark

- n=132 autograft ITB
- FU: 4 years
- 20% failure rate in women
- Not recommendable in women

Allograft

- Patellar tendon with two bone plugs
- Achilles tendon with one bone plug
- Semi-tendinosus and gracilis tendons
- Tibialis anterior and posterior tendons

Allograft



Allograft

- Fresh frozen
- Cryo-preserved
 - Gamma irradiation (1.7mRd)
 - Ethylene oxide

Allograft +

- No donor site morbidity
- Multiple-ligaments reconstructions
- Knee dislocation
- Revision
- Elderly patients
- Selected cases (Artists-dancers-models)

Allograft -

- Infectious agent transmission
- Immune reaction
- Slower maturation (revascularisation-cell repopularisation)
- Deterioration of implanted tissue overtime
- Failure more frequent Harner et al *Clin Orthop* 1996
Shelton et al *Arthroscopy* 1997
- No difference in clinical outcome at 3 and 5 years

Allograft outcome

Analysis of Outcomes With 5-Year

Gary G. Poehlein, M.D.,
T. Michael DeMauro, M.D.

Purpose: To prospectively evaluate outcomes with either Achilles tendon or bone-patellar tendon-bone (BPTB) autograft or allograft in patients who underwent anterior cruciate ligament reconstruction. **Methods:** Objective measures of knee stability, patient subjective assessment of pain, and International Knee Documentation Committee (IKDC) scores were measured at 5, 10, and 15 years postoperatively. **Results:** There were no significant differences in IKDC scores, Lysholm scores, or patient subjective assessment of pain between the three groups at any time point. **Conclusion:** Long-term outcomes are similar between the three groups.

A Retrospective Study of Infection Following

Laurie M. Katz, M.D.,
William Reichmann, M.D.

Purpose: To compare the incidence of infection in autograft and allograft reconstruction. **Methods:** Retrospective review of all ACL reconstructions performed between 1990 and 2012. **Results:** The incidence of infection was significantly higher in the allograft group (4.3%) compared to the autograft group (1.2%).

A Meta-analysis of Patellar Tendon Allograft in ACL Reconstruction

Aaron J. Krych, M.D.

Purpose: Studies have suggested that patellar tendon allograft is associated with a higher rate of failure compared to autograft. **Methods:** A meta-analysis of all studies comparing patellar tendon allograft to autograft for ACL reconstruction. **Results:** The pooled relative risk of failure for allograft compared to autograft was 1.83 (95% CI 1.13-3.00).

Systematic Review

Anterior Cruciate Ligament Reconstruction Compared With Allograft

Cory J. Lamblin, M.D.

Purpose: Allograft anterior cruciate ligament reconstruction is an alternative to autograft. **Methods:** Systematic review of all studies comparing allograft to autograft for ACL reconstruction. **Results:** Allograft was associated with a higher rate of failure compared to autograft.

Anterior Cruciate Ligament Reconstruction With Bone-Patellar Tendon-Bone Graft: Comparison of Autograft, Fresh-Frozen Allograft, and γ -Irradiated Allograft

Lin Guo, M.D., Liu Yang, M.D., Ph.D., Xiao-jun Duan, M.D., Rui He, M.D.,
Guang-xing Chen, M.D., Fu-you Wang, M.D., and Ying Zhang, M.D.

Purpose: To compare clinical follow-up results of anterior cruciate ligament (ACL) reconstruction using (1) autologous, (2) fresh-frozen allogeneic, and (3) γ -irradiated allogeneic bone-patellar tendon-bone (BPTB). **Methods:** From February 2002 to January 2006, 187 patients received BPTB ACL reconstruction at our center. One hundred forty-two consecutive patients who had received single-bundle BPTB ACL reconstruction were included in this study. **Results:** The mean duration of follow-up was 6.7 ± 1.5 years (range, 4.2 to 8.2 years). There were 3 cases of acute synovitis due to immunologic rejection (fresh-frozen allografts) and 6 cases of failure (γ -irradiated allografts). **Conclusion:** KT-1000 examination showed more anterior laxity in the γ -irradiated allograft group compared with the autograft and fresh-frozen allograft groups ($P < .05$). The Lysholm, Irgang, and Larson activity scales showed no difference among the 3 groups ($P > .05$). **Level of Evidence:** Systematic review, Level III, retrospective comparative study.

The anterior cruciate ligament is the most commonly injured ligament in the United States.¹⁻⁴ Traditionally, reconstruction with hamstring or patellar tendon is the technique of choice. However, there is concern regarding donor site morbidity.

Bone-patellar tendon-bone (BPTB) is widely used for reconstruction of ACL-deficient knees because of its excellent initial mechanical properties, durability, and short-term follow-up.¹ However, studies have shown that the harvesting of the central third of the donor site has associated donor site morbidity.

Anterior cruciate ligament (ACL) rupture is among the most common orthopedic injuries, particularly among athletes. ACL rupture can also lead to an increased risk of chondral or meniscal injury and athletic performance.² As a result, ACL reconstruction has generated significant interest among surgeons and patients.

Given the indisputable importance of ACL reconstruction, many surgeons have attempted a multi-

anterior cruciate ligament (ACL) rupture is a common sports injury. Arthroscopically assisted reconstruction of the ACL is the most frequently performed technique. Autograft is routinely used, but the amount of autologous tissue available is limited by the potential everlasting functional disability created by a defect at the donor site. Furthermore, there are poten-

tial complications with the use of autograft patellar tendon, including extensor mechanism failure, and autograft hamstring, including small tendon size.^{1,2} ACL reconstruction with allograft could be an alternative solution. Some allografts can be used safely for ACL reconstruction while yielding different amounts of primary tension and different capacities for graft healing and graft incorporation.³ Considering the primary tension and capacity of healing in the tunnel, bone-patellar tendon-bone (BPTB) is still considered the gold standard.⁴ Using allograft BPTB could avoid donor-site complications such as patellar fracture,⁵⁻⁷ contracture of the patellar tendon,^{8,9} patellofemoral symptoms,^{10,11} and quadriceps weakness.¹² The most frequently used allografts include fresh-frozen and γ -irradiated BPTB.³ However, whether the advantages of autologous BPTB are maintained after these

From the Department of Orthopaedic Surgery, Writson-Salmon School of Medicine, Winston-Salem, NC (G.G.P., T.M.D.). Address correspondence and reprint requests to Dr. Poehlein, Department of Orthopaedic Surgery, School of Medicine, Medical Center Blvd, U.S.A. E-mail: gpoehlein@wakehealth.edu

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Note: To access the supplementary material, visit the July 2005 issue of *Arthroscopy: The Journal of Arthroscopic and Related Surgery*.

From the Department of Orthopaedic Surgery (L.M.K., T.C.B., P.F.P., D.J.W.) and the Department of Orthopaedic Surgery, Boston, MA (L.M.K.). T.C.B. is a consultant for LifeNet. Received March 3, 2008; accepted March 12, 2008. Address correspondence and reprint requests to Dr. Katz, M.D., New England Baptist Hospital, 125 Parker Hill Ave., Boston, MA. E-mail: lkatz@nebop.com

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From the Departments of Orthopaedic Surgery (D.L.D.) and Biostatistics (T.L.H.), Mayo Clinic, Rochester, MN, U.S.A. The authors report that they have no conflicts of interest. Received November 18, 2012; accepted January 18, 2013. Address correspondence and reprint requests to Dr. Lamblin, Department of Orthopaedic Surgery, William Beaumont Army Medical Center, El Paso, Texas, U.S.A. E-mail: cjl@wbaac.com

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Technique in ACL Auto versus Allo

A Meta-analysis of Patellar Tendon Autograft Versus Patellar Tendon Allograft in Anterior Cruciate Ligament Reconstruction

Aaron J. Krych, M.D., Jeffrey D. Jackson, M.D., Tanya L. Hoskin, M.S.,
and Diane L. Dahm, M.D.

In this meta-analysis, graft failure and functional outcome as measured by single-leg hop test favored ACL reconstruction with BPTB autograft over BPTB allograft. However, when irradiated and chemically processed grafts were excluded, no significant differences were found in all measurable outcomes.

- Delayed "ligamentisation"
- Higher failure rate (4x)
- No increase risk of infection

Krych et al *Arthroscopy* 2008
Scheffler et al *Arthroscopy* 2008
Kaeding et al *Sports Health* 2011
van Eck et al *Am J Sports Med* 2012

Conclusions

- Objective information to the patient
- Decision made with the patient
- Relation of confidence

Individualisation of the Ttr !!!!

Mark your calendar

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16th ESSKA Congress
May 14-17, 2014





Thank you for listening

