

# ANATOMICAL “RIBBON” ACL RECONSTRUCTION

A 4-Year Follow-Up

Evaluation of Surgery Outcomes Including Physical Examination, and Post-Op MRI and CT Scans Assessment

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NO FINANCIAL CONFLICTS  
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**I AM A CONSULTANT FOR:  
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ARTHREX**



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2023



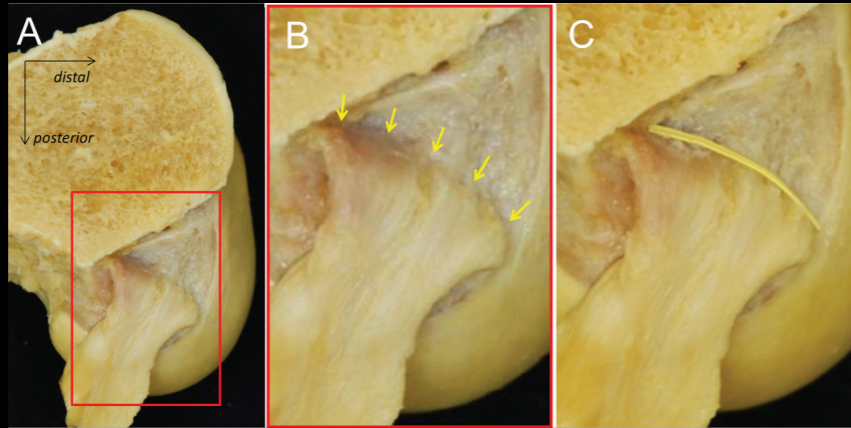
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Massachusetts  
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# INTRODUCTION

## “**Ribbon**” ACL concept

The paradigm of anterior cruciate ligament reconstruction (ACL-R) is undergoing constant changes. There are several techniques used around the world, stirring much discussion on which approach is optimal for patients recovery and long-term outcomes.



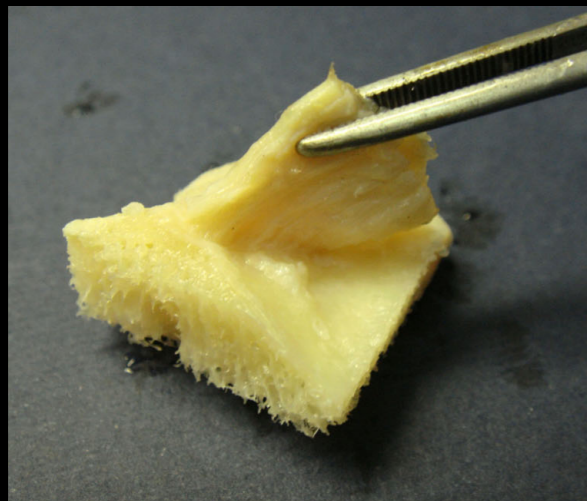
### Anatomic Variations of the Lateral Intercondylar Ridge

#### Relationship to the Anterior Margin of the Anterior Cruciate Ligament

Sachiyuki Tsukada,\* MD, Hitomi Fujishiro,\* MT, Kentaro Watanabe,\* Akimoto Nimura,\* MD, PhD, Tomoyuki Mochizuki,† MD, PhD, Pasuk Mahakkanukrauh,‡ MD, PhD, Kazunori Yasuda,§ MD, PhD, and Keiichi Akita,\*|| MD, PhD  
Investigation performed at Tokyo Medical and Dental University, Tokyo, Japan, and Chiang Mai University, Chiang Mai, Thailand

### Cadaveric Knee Observation Study for Describing Anatomic Femoral Tunnel Placement for Two-Bundle Anterior Cruciate Ligament Reconstruction

Tomoyuki Mochizuki, M.D., Ph.D., Takeshi Muneta, M.D., Ph.D., Tsuyoshi Nagase, M.D., Shin-ichi Shirasawa, M.D., Ph.D., Kei-ich Akita, M.D., Ph.D., and Ichiro Sekiya, M.D., Ph.D.



### Ribbon like appearance of the midsubstance fibers of the Anterior Cruciate Ligament close to its femoral insertion site. A cadaveric study including 111 knees.

Robert Śmigielski, MD, Urszula Zdanowicz, MD, Michał Drwięga, MD, Bogdan Ciszek, MD, PhD, Beata Cizkowska-Lysoń, MD, PhD, Pau Golano, MD, Siebold Rainer, MD, Assoc.Prof. Knee Surgery, Sports Traumatology, Arthroscopy

*The configuration of the natural ACL midsubstance is **not oval**, but rather flat, looking like a “lasagna”.*

*Mochizuki et al., 2006*

### Ribbon like appearance of the midsubstance fibres of the anterior cruciate ligament close to its femoral insertion site: a cadaveric study including 111 knees

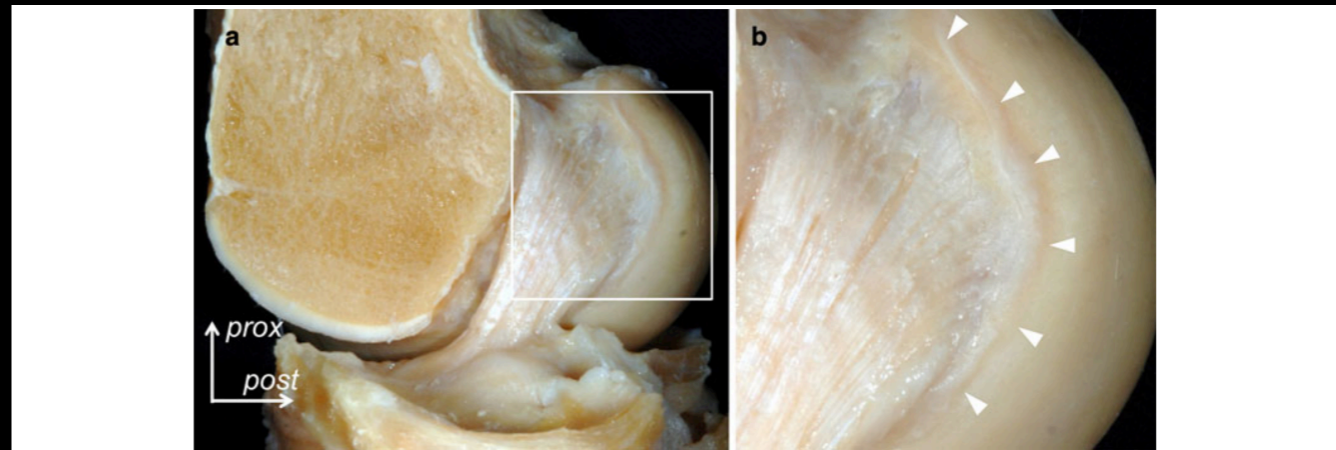
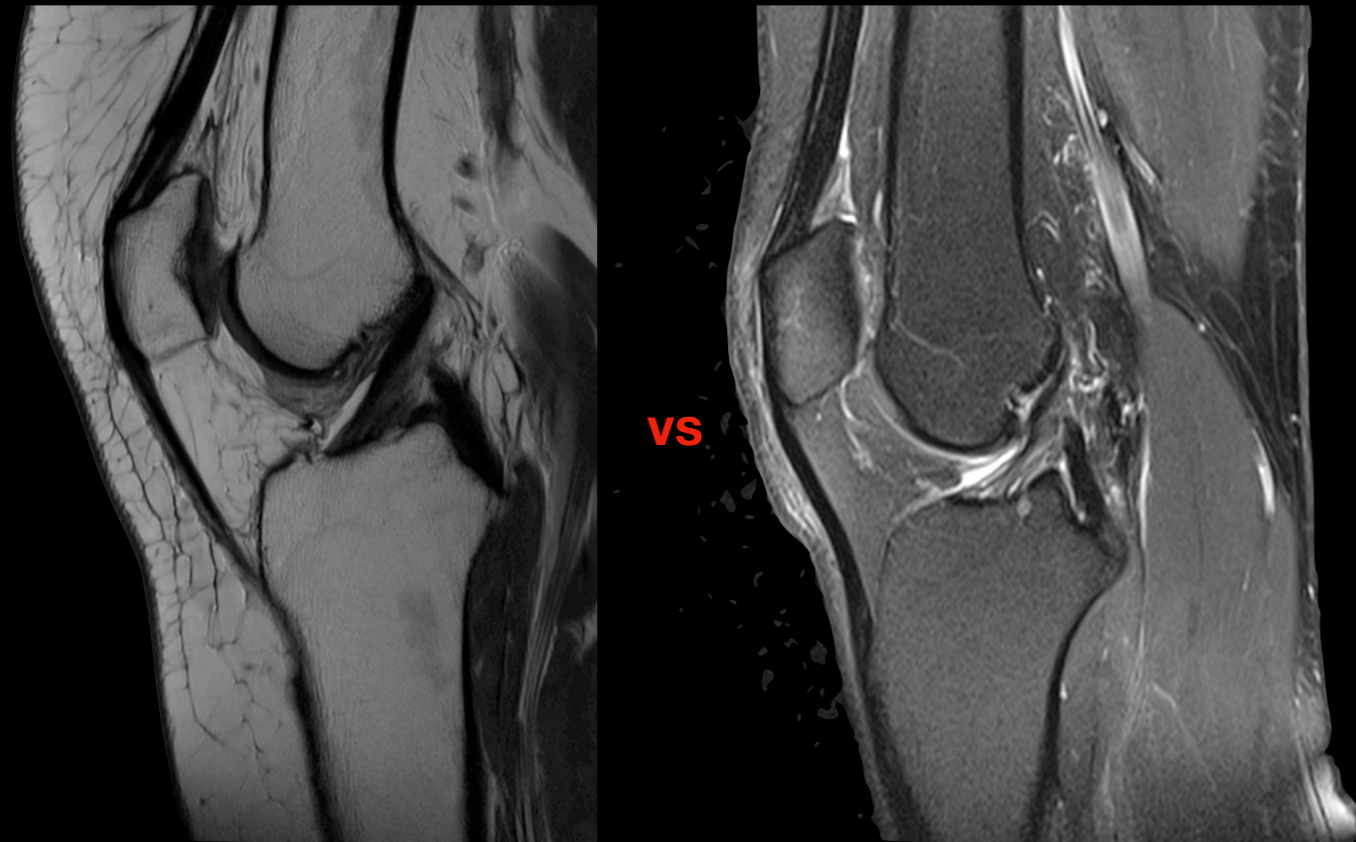
Robert Śmigielski · Urszula Zdanowicz · Michał Drwięga · Bogdan Ciszek · Beata Cizkowska-Lysoń · Rainer Siebold





# INTRODUCTION

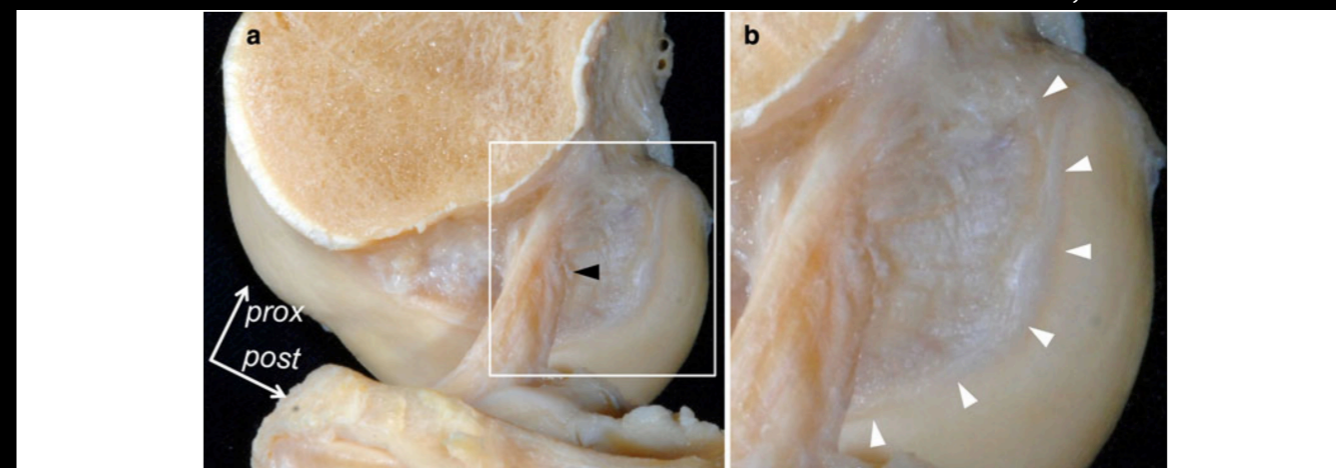
## “Functional bundles”?



**Fig. 2** Static observation of the mid-substance and fan-like extension fibres at full extension. **a** Both the mid-substance fibres and the fan-like extension fibres were aligned parallel to the intercondylar roof without *curving*. **b** High-magnification view of ACL fibres on the

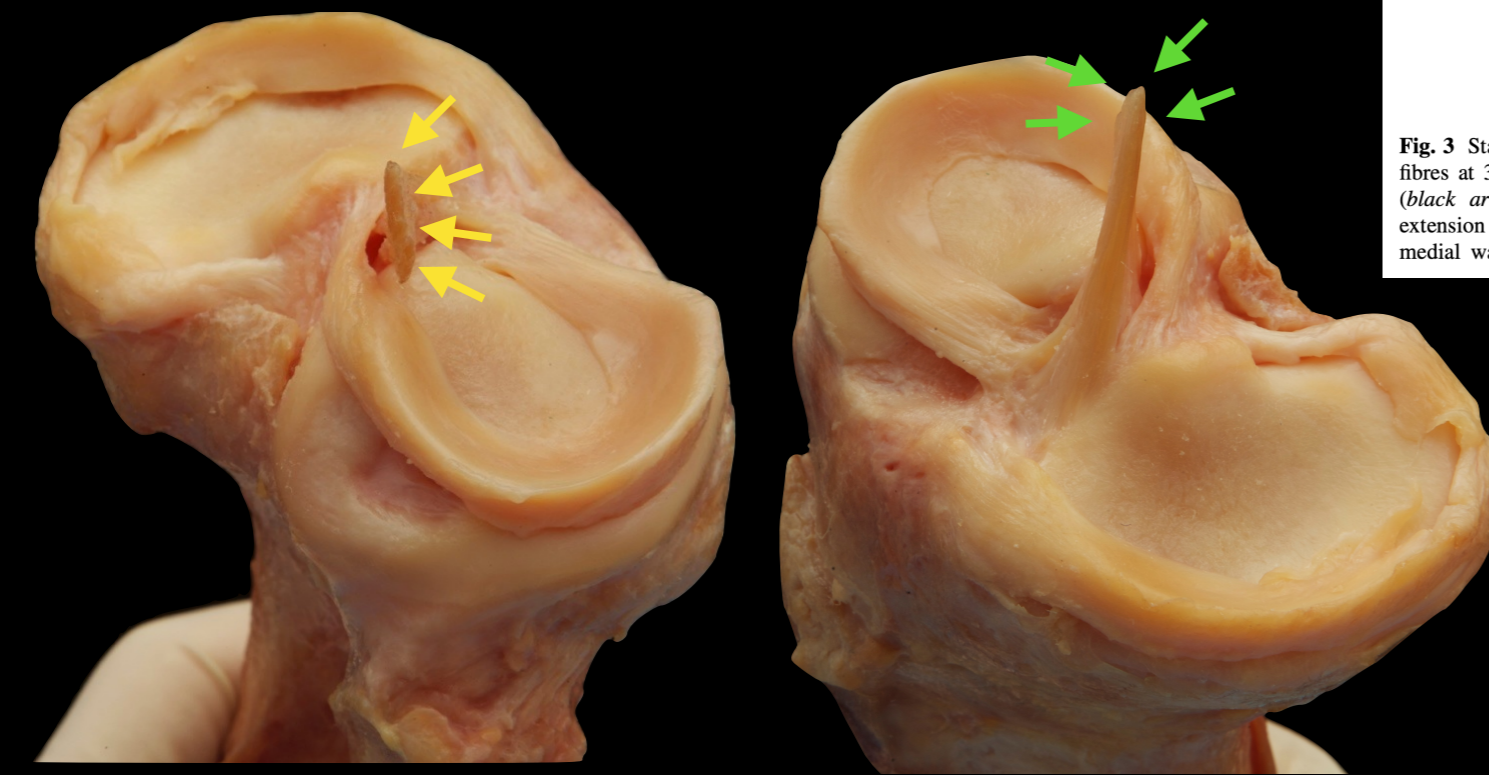
medial wall of lateral condyle. The fan-like extension fibres reached the margin of articular cartilage (*white arrowheads*) and tended to adhere to the medial wall and became rather sparse as they approached the articular cartilage

*Mochizuki et al., 2014 KSSTA*



**Fig. 3** Static observation of the mid-substance and fan-like extension fibres at 30° knee flexion. **a** The mid-substance fibres were curved (*black arrowhead*) and changed the direction from the fan-like extension fibres. **b** High-magnification view of ACL fibres on the medial wall of lateral condyle. The fan-like extension fibres were

adhered to the bone surface and the fibre location and orientation in relation to the bone surface did not change, while the orientation of the mid-substance fibres did change with knee flexion. *White arrowheads* the articular margin



The way the **ribbon-like structure** behaves while knee flexion and extension can create an illusion of a double-bundle structure, therefore, we can speak of "**functional bundles**".

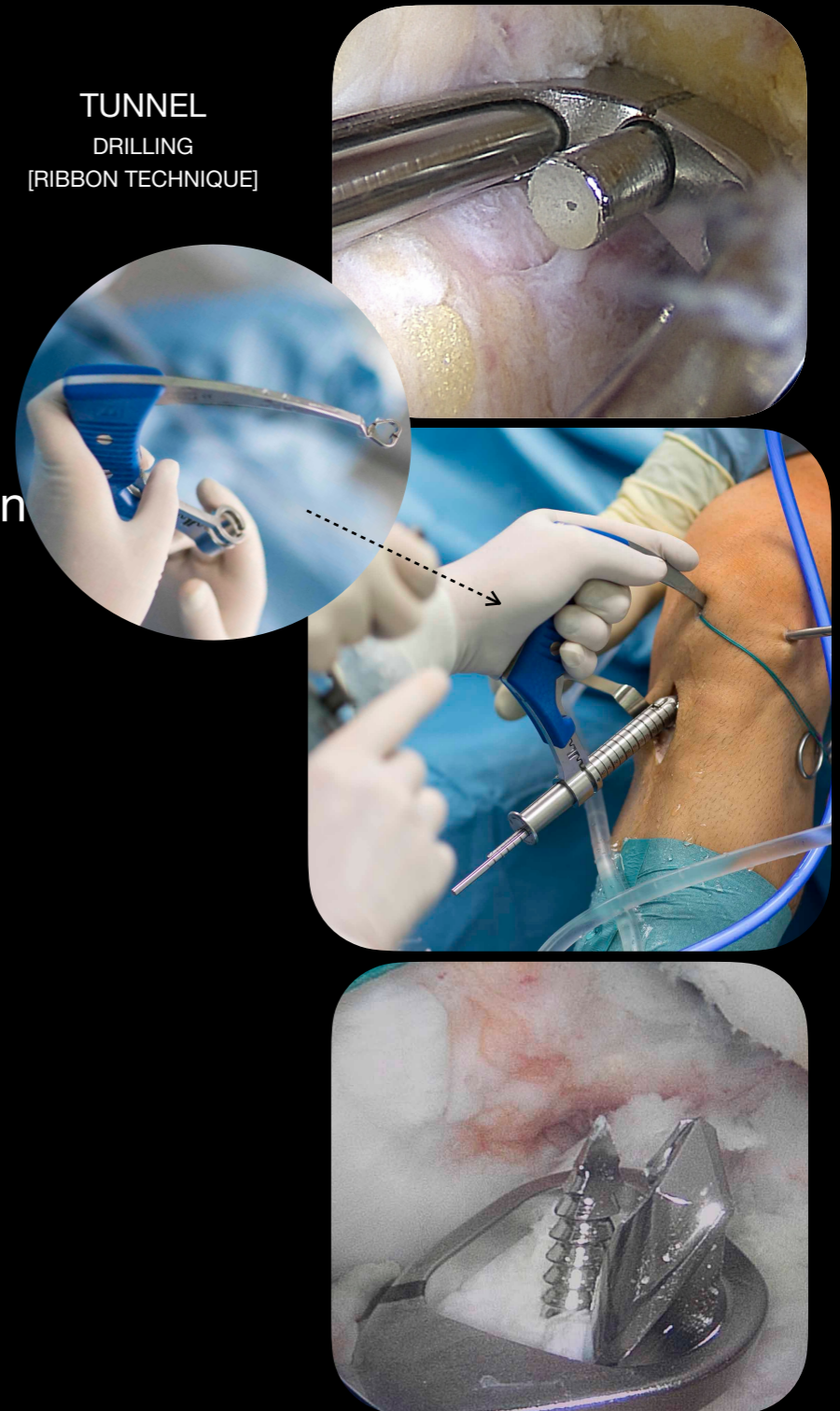


# MATERIAL & METHODS

## OVERVIEW

- **131 cases** of ACL-R recorded in 2018 and 2022 with the mean follow-up of 38 weeks (9 months)
  - 99 primary reconstructions
  - 12 one-stage revisions
  - 20 two-stage revisions
- **1 surgical team** using “ribbon” technique reconstruction
- **GRAFT CHOICE** (autograft):  
95,15% **quad** & 4,85% **semiT**
- **in all cases there were concomitant injuries, incl.:**
  - meniscal lesions
  - chondromalacia grades II/III & III/IV
  - MCL rupture/partial tear
  - posterolateral tibia fracture

TUNNEL  
DRILLING  
[RIBBON TECHNIQUE]





# MATERIAL & METHODS

## OBSERVATION PROTOCOL

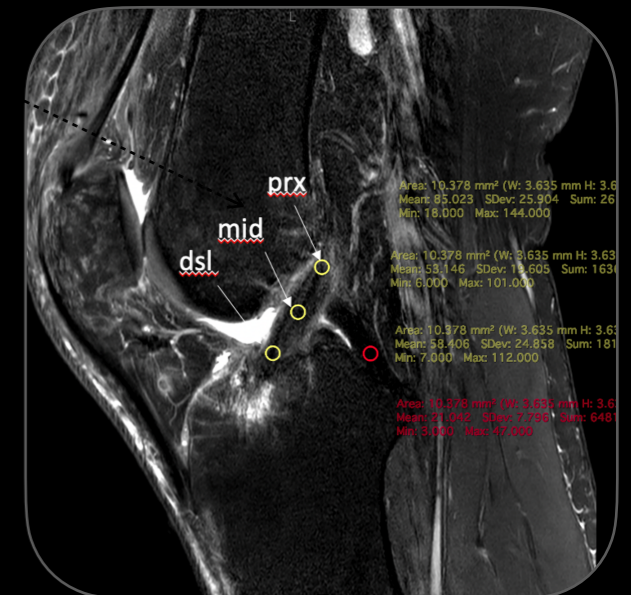
### PHYSICAL EXAMINATION

- **all patients** had a pre- and post-op consults, incl. palpation, ROM assessment, stability assessment
  - follow-up consults were recommended 3 (ultrasound-guided HD PRP injection), 6, and 12 weeks, then every 3 months up to 2 years



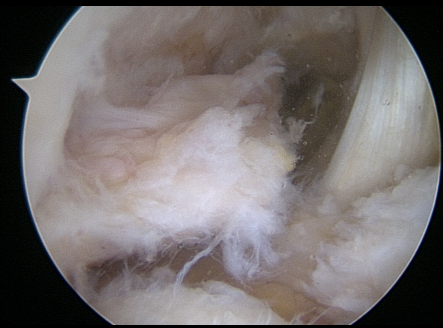
### IMAGING DIAGNOSTICS

- **all patients** did pre- and post-op MRI scans
  - follow-up MRIs were ordered at **3, 6, 9, 12, and 18 and 24 months** - graft maturation (signal), bone cysts/oedema presence, soft tissues healing stage, intra-articular scar formation, and tibia subluxation were evaluated
- 42 pre-op CT scans 92 post-op CTs (initially CT was ordered when **posterolateral tibia fracture** was suspected & for **revision surgeries**, later in the study, the post-op protocol was extended by a routine CT scan).

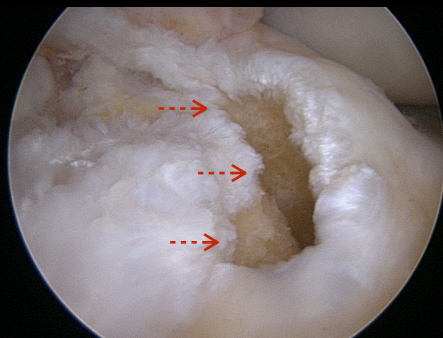
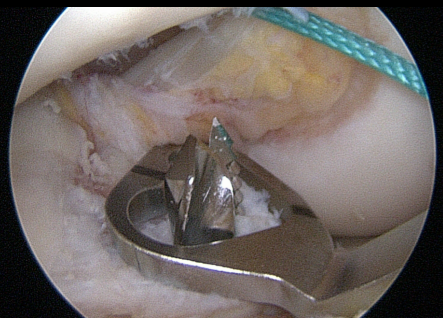
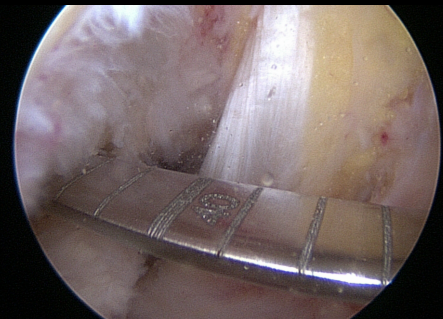
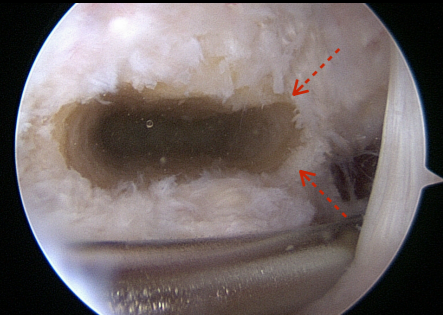




# RESULTS OVERVIEW



ACL-R RIBBON



- no major complications such as:
  - donor-site morbidity
  - pain at donor-site
  - infections
  - spontaneous re-ruptures
- **2 traumatic re-ruptures** (1 primary and 1 revision case)
- all primary patients returned to their expected level of **daily activity** at 2-3 weeks post-op
- patients returned to their **expected level of physical activity** at 6 months post-op on the average (4 - 12 months)
- overall patient-reported satisfaction at 9 month follow-up: **very good to excellent**



*All patients reported significant improvement in their everyday functioning compared to the time before the surgery.*



# RESULTS

# FUNCTION

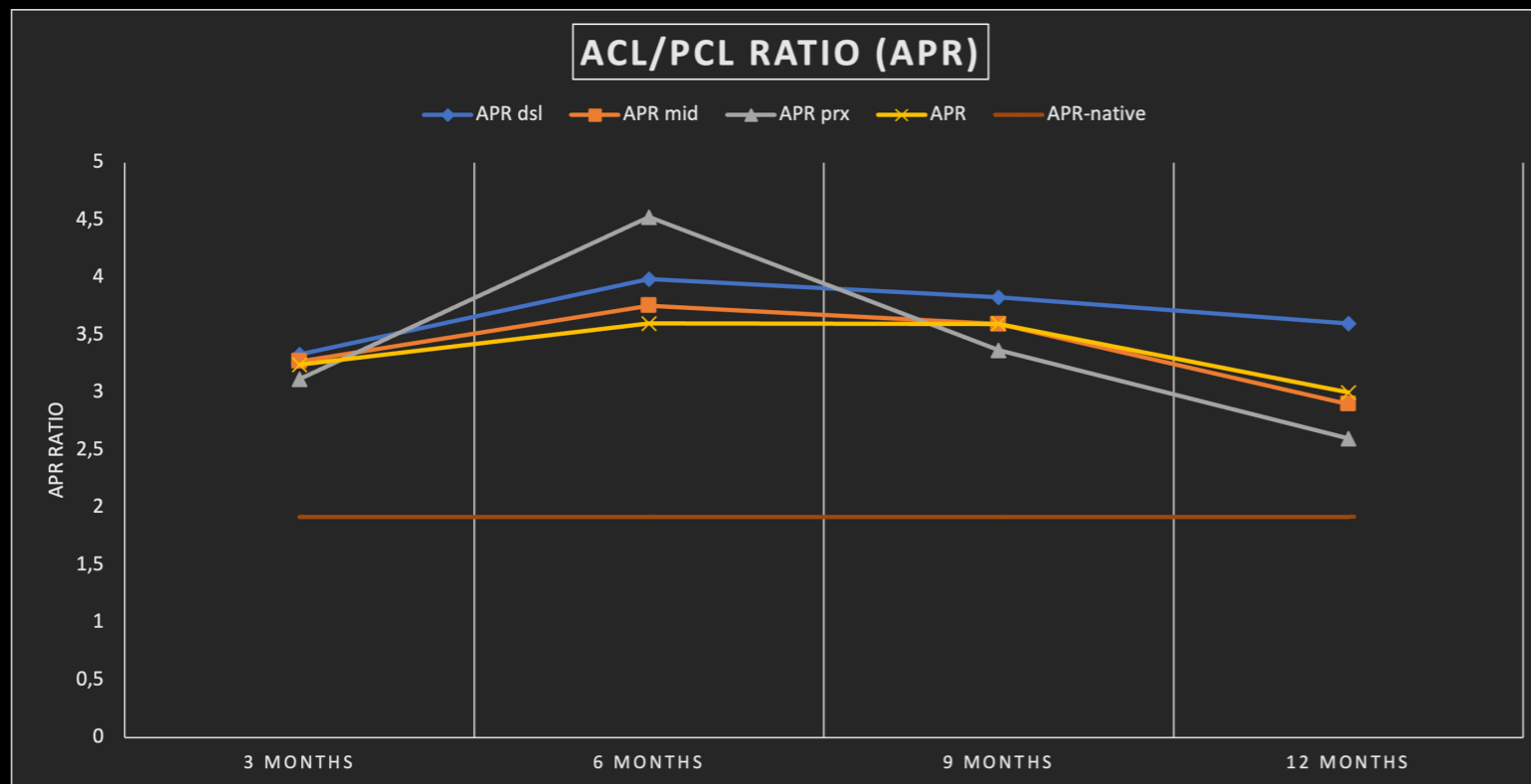
- full knee extension at 6 weeks post-op in ca. 92% of cases
- full knee flexion at 12 weeks post-op in ca. 90% of cases (cases w/ out meniscus suturing)
- no recurrent instability confirmed during follow-up physical examinations
  - symmetrical stability in both legs
  - negative Lachman test
  - negative anterior drawer
  - negative pivot-shift - where assessed
- very good QF activation and contraction
  - function similar to the contralateral leg restored at **4,5 months on the average (ranging 4-6 months)** - achieved through intensive physical therapy, monitored by the operator





# RESULTS

## STRUCTURE



Properly healing anatomical structure restored at the **average of 9 months** post-op.

Of note, based on the study of post-operative MRIs conducted along with the PT team (*Stawińska et al.*) **the period between 3 to 6 months seems to be critical for the graft maturation** process.

- **no tunnel malpositioning** on control CTs
- **no tunnel widening** monitored on CTs, no significant changes recorded
- **no post-op anterior tibia subluxation** recorded on post-op MRIs
- **good graft remodelling** monitored on MRIs at **9 months** on the average compared to the non-injured structure signal

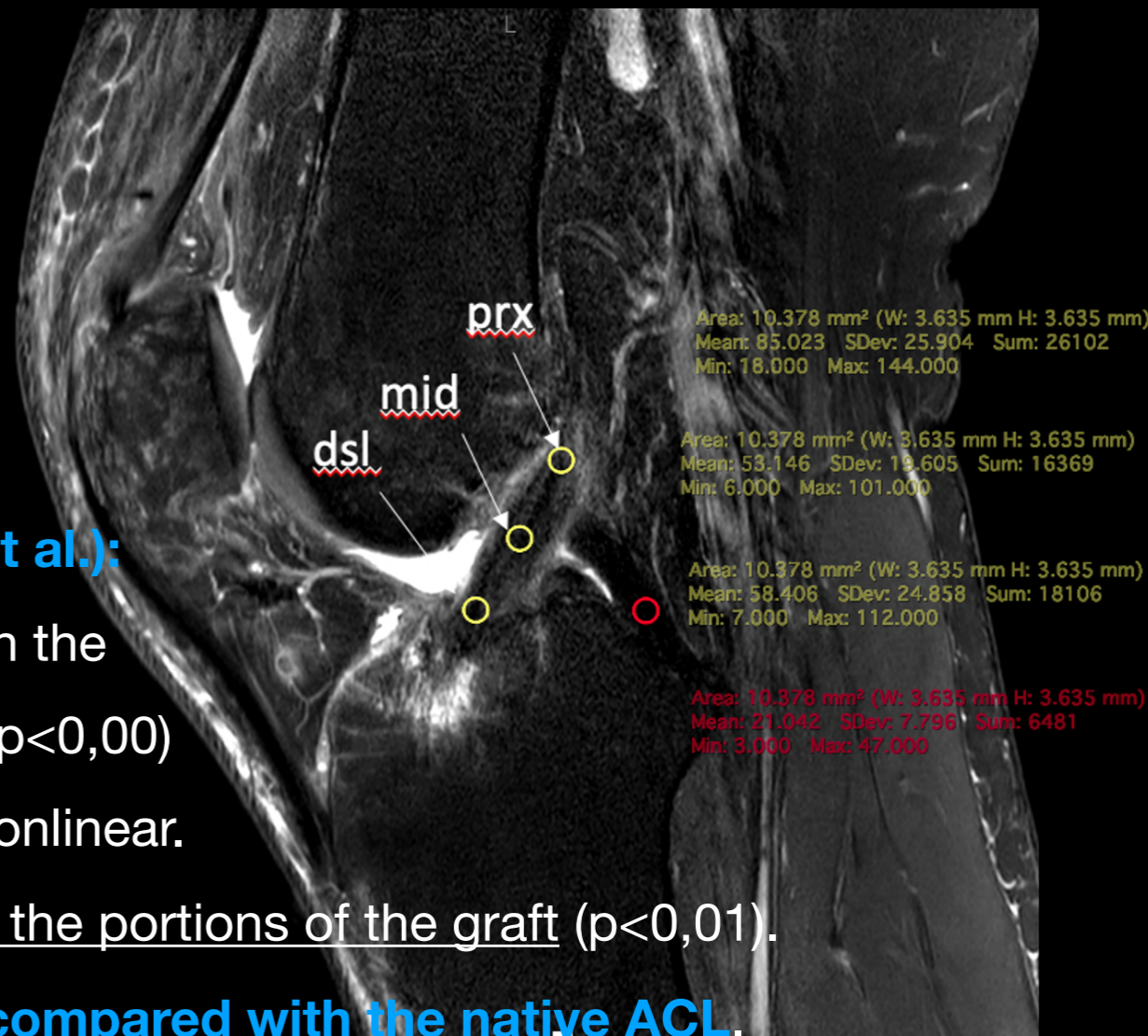


# RESULTS

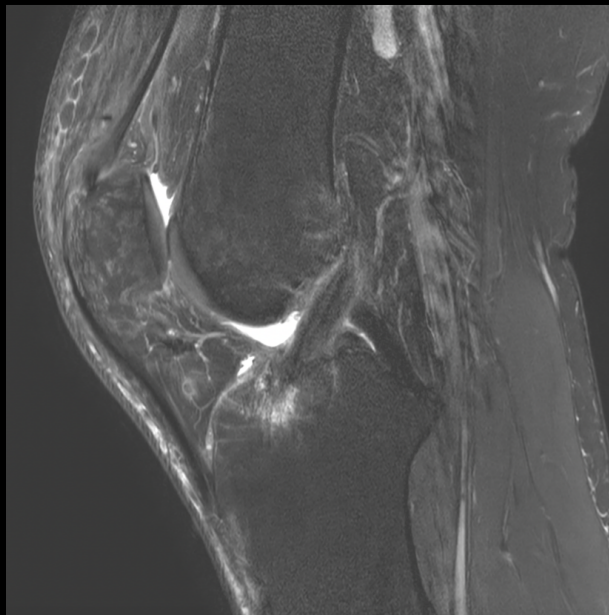
## MRI OBSERVATION

Selected conclusions from the MRI study (Stawińska et al.):

1. Median signal intensity (MSI) has changed significantly in the proximal ( $p < 0,001$ ) mid-substance ( $p < 0,001$ ) and distal ( $p < 0,00$ ) portion of ACL graft over months, but the change was nonlinear.
2. The most hyper-intensive period was in **6 months** for all the portions of the graft ( $p < 0,01$ ).
3. The quadriceps graft had approximately **85% MRI -SI compared with the native ACL**.



3 MONTHS



6 MONTHS



9 MONTHS



12 MONTHS



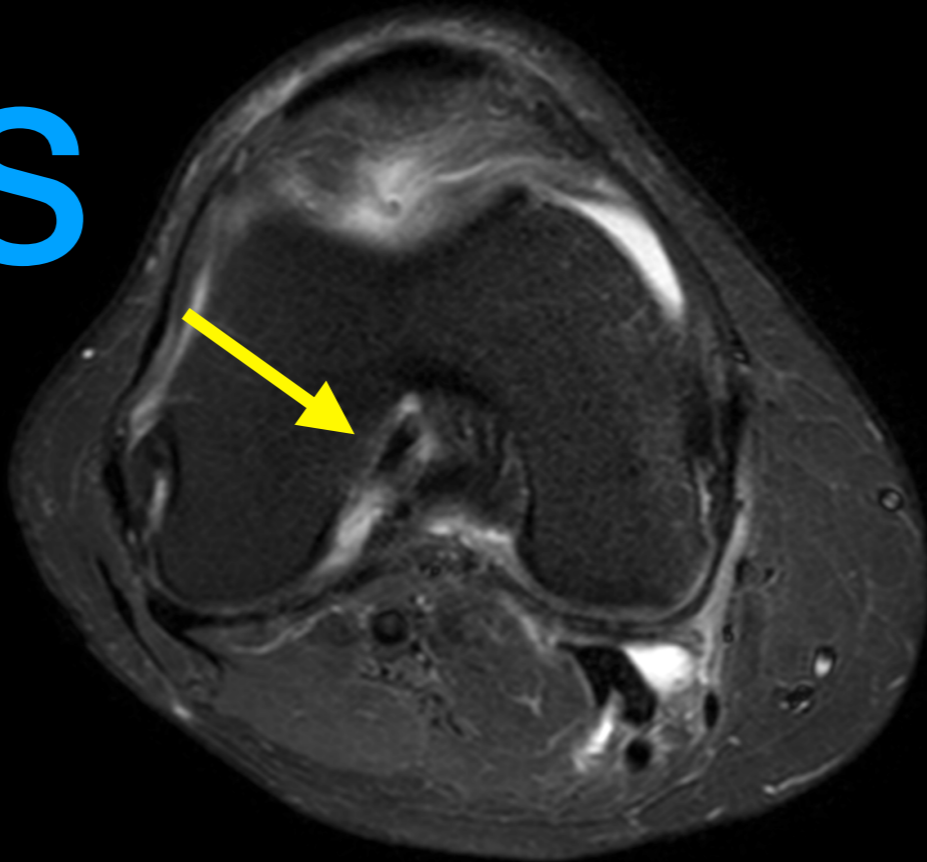
THE GRAFT MATURATION PROCESS OVER TIME





# RESULTS

6 MOTNHS POST-OP  
3T MRI





*Recent anatomical research indicates that the ACL's midsubstance is in fact flat.*

## CONCLUSIONS

Still, the way the ribbon-like structure behaves while knee flexion and extension can create an illusion of a double-bundle structure, therefore, we can speak of "*functional bundles*", but not structural ones. The recently-established ACL-RR takes into account both graft's and tunnels' anatomical shape and positioning, allowing for a truly anatomical reconstruction, showing very promising long-term outcomes, especially with regard to the graft incorporation failure rate, allowing patients to safely return to their normal lifestyle in relatively short time.

## ARGUMENTS FOR ANATOMIC "RIBBON" ACL-R

RESTORING NATIVE ACL ANATOMY results in:

- ✓ MORE ACCURATE KNEE MECHANICS RESTORATION - decreases chances of non-traumatic re-rupture, improves knee function
- ✓ rectangular femoral tunnel - BETTER GRAFT INGROWTH
- ✓ GREAT PATIENT OUTCOMES IN 4-YEAR FOLLOW-UP - assessed clinically and in CT and MRI scans



# Suggested Reading:

## ANATOMY:

- Śmigielski R, Zdanowicz U, Drwięga M, Ciszek B, Ciszewska-Łysoń B, Siebold R. **Ribbon like appearance of the midsubstance fibres of the anterior cruciate ligament close to its femoral insertion site: a cadaveric study including 111 knees.** Knee Surg Sports Traumatol Arthrosc. 2015;23 (11):3143-3150.
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- Siebold R, Schuhmacher P, Fernandez F, Śmigielski R, Fink C, Brehmer A, Kirsch J. **Flat midsubstance of the anterior cruciate ligament with tibial “C”-shaped insertion site.** Knee Surg Sports Traumatol Arthrosc. 2015;23 (11):3136-3142.
- Śmigielski R, Zdanowicz U. **A new approach to ACL anatomy: The Ribbon Concept.** ASPETAR Sports Medicine Journal. 2015
- Śmigielski R, Zdanowicz U. **Anatomy of ACL Insertion: Ribbon.** Controversies in the Technical Aspects of ACL Reconstruction: An Evidence-Based Medicine Approach. Springer; 2017

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- Lord BR, El-Daou H, Zdanowicz U, Śmigielski R, Amis AA. **The Role of Fibers Within the Tibial Attachment of the Anterior Cruciate Ligament in Restraining Tibial Displacement.** Arthroscopy. 2019;35 (7):2101-2111.

## SURGICAL TECHNIQUE:

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- Śmigielski R, Zdanowicz U, Drwięga M, Ciszek B, Williams A. **The anatomy of the anterior cruciate ligament and its relevance to the technique of reconstruction.** Bone Joint J. 2016;98-B (8):1020-1026.