

Pivot-shift measurement-based approach for improving ACL reconstruction

Yuichi Hoshino, Koji Nukuto, Kyohei Nishida,
Kanto Nagai, Ryosuke Kuroda

Kobe University, Kobe, JAPAN

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Croucher summer course 2026

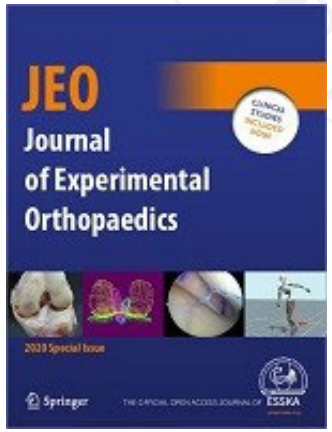
COI Disclosure Information

Presenter : Yuichi Hoshino

I have no financial relationships to disclose.

- I am an associate editor for

JEO



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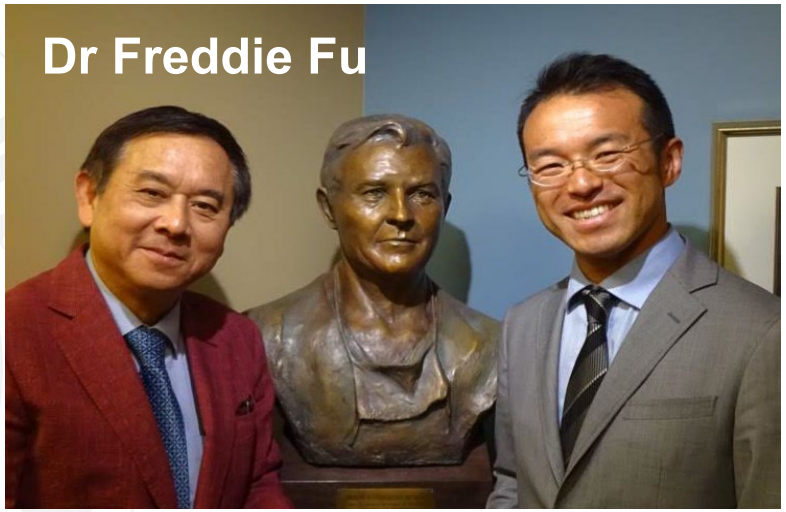
Journal of the AAOS® Global Research & Reviews

Who am I… : Surgeon & Researcher

2000- Orthopaedic & Sports medicine surgeon @ Kobe Univ.

2005- ACL surgery and research

2009-2012 Research @ Pittsburgh Univ.



Currently

- **100+/year – ACL-Rs**
- **180 publications**
- **31 H-index**





Who am I… : Sports Physician

➢Rugby

- Kobelco Kobe Steelers







➢Baseball

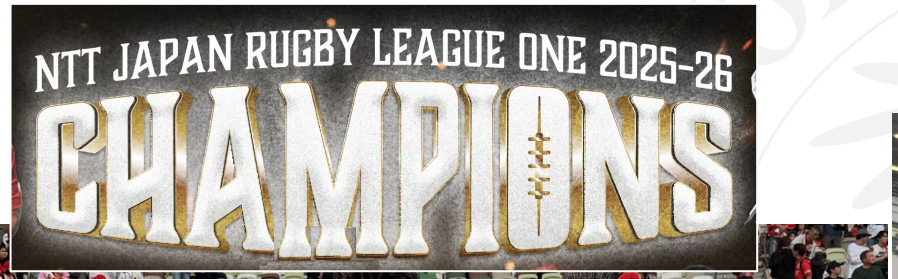
- Orix Buffaloes



Who am I… : Sports Physician

➢Rugby

- Kobelco Kobe Steelers









Who am I… : Sports Physician

➢ American Football 2004~

- 2004-2006 College: Kyoto Sangyo Univ.
- 2004-2009 College: Kobe Univ.
- 2004-2009 Amateur senior: Iwatani Sidewinders
- **2012 JAPAN National Team (U-19): The 2nd World Championship**
- 2012-2017 College: Konan Univ.
- 2014-2015 College: Kobe Univ.
- **2017- College: Kansai Univ.**

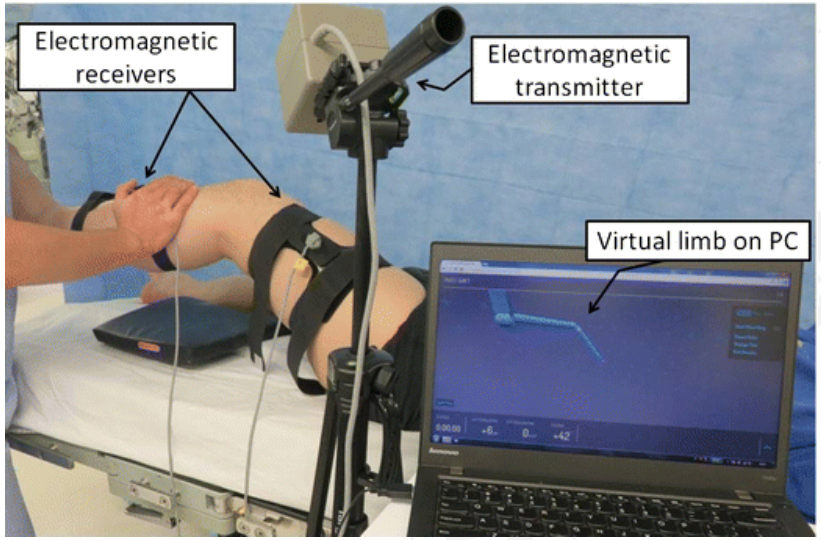




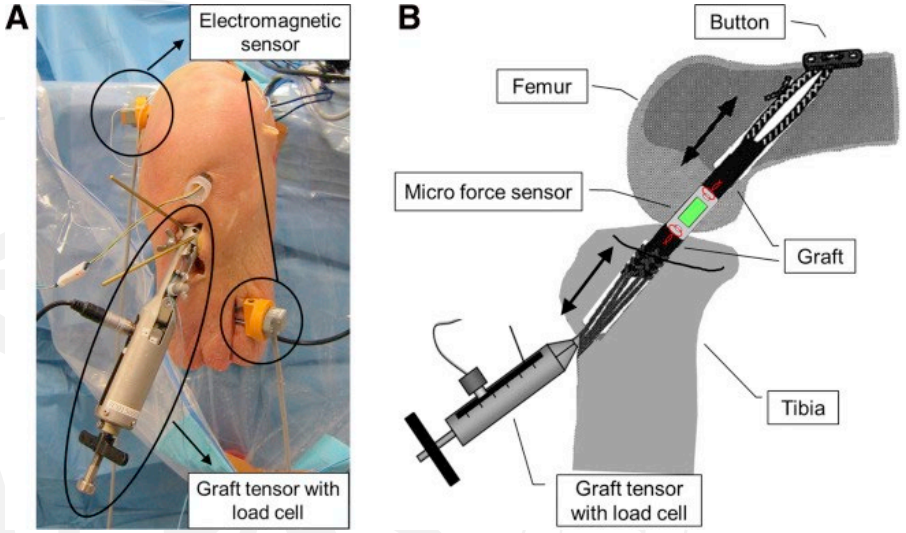


What I have done…

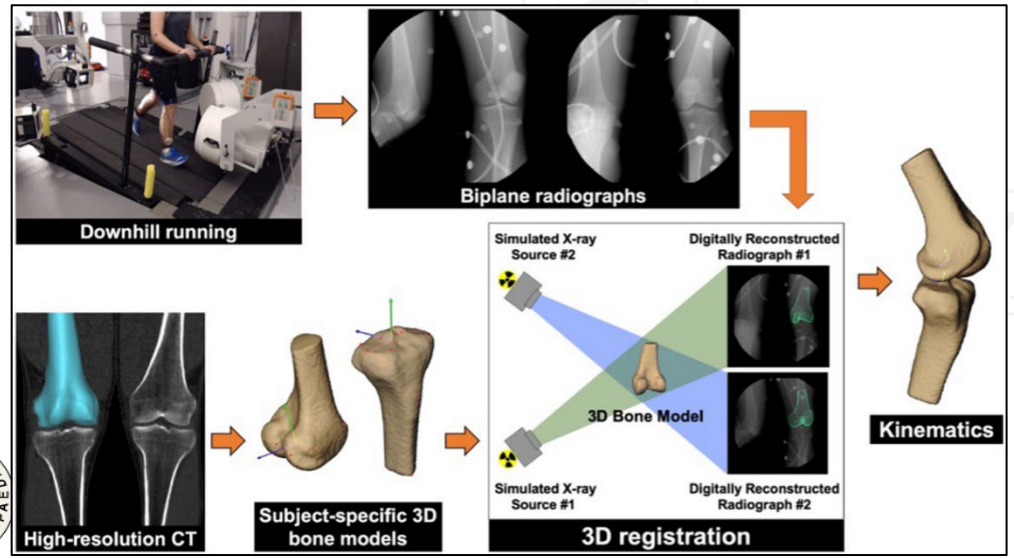
In vivo EMS



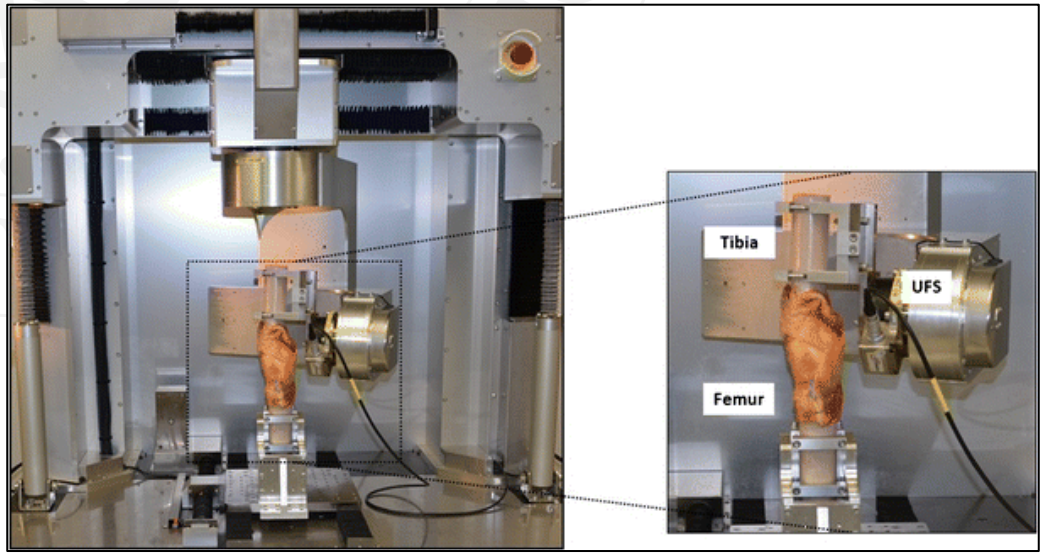
Cadaver EMS



In vivo biplane X-ray



Cadaver robot



Agenda

Sports Biomechanics Research

as a Sports Medicine Surgeon/Researcher/Editor

<u>All about ACL (anterior cruciate ligament)</u>

1. What is the pivot-shift from clinical POV?
2. How can we evaluate the pivot-shift "objectively"?
3. Other measurements for ACL research
4. New topics about ACL

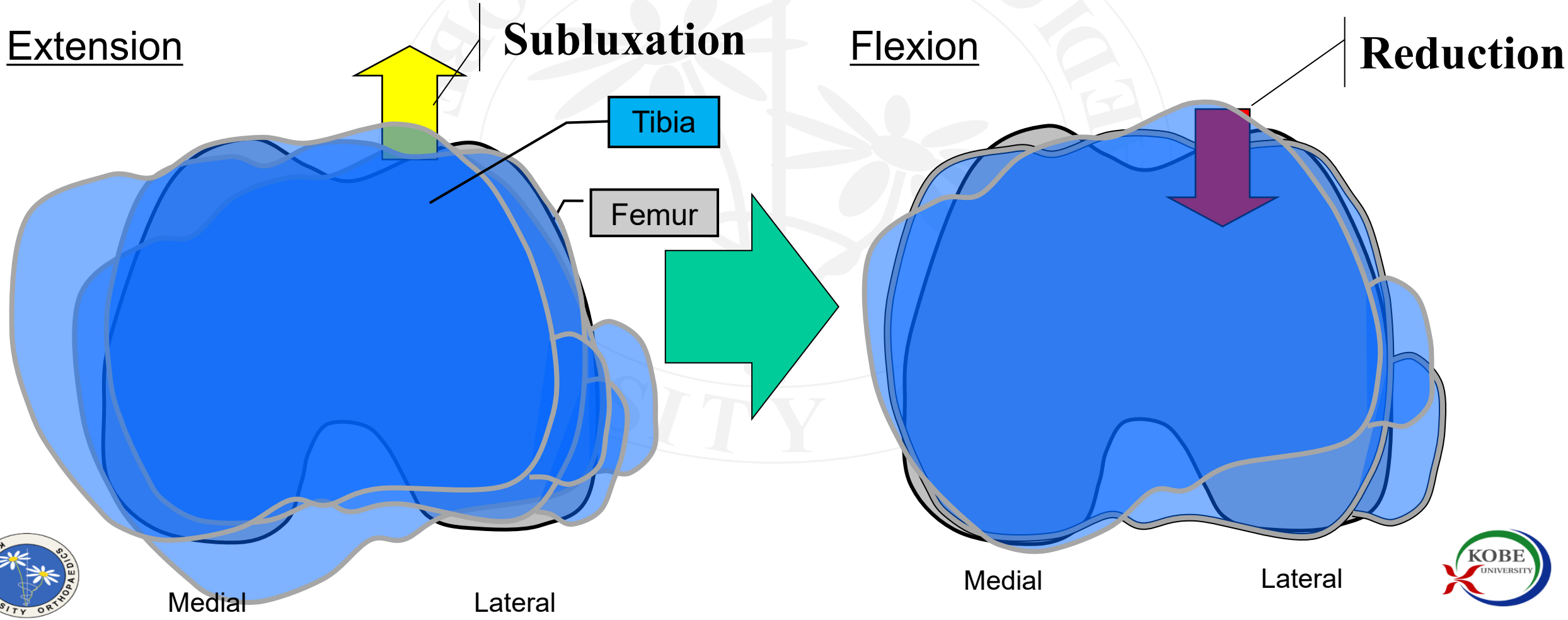
Pivot-shift - Main symptom of the ACL injury



What happens during the Pivot-shift??

“ **forward subluxation** of the lateral tibia plateau on the femoral condyle in extension, and **spontaneous reduction** in flexion.”

Galway RD, et al. J Bone Joint Surg Br 1972



What keeps patients from RTS?

PLOS ONE

RESEARCH ARTICLE

Understanding the psychological mechanisms of return to sports readiness after anterior cruciate ligament reconstruction

Bernard X. W. Liew[1]*, **Julian A. Feller**[2], **Kate E. Webster**[3]

1 School of Sport, Rehabilitation and Exercise Sciences, University of Essex, Colchester, United Kingdom, **2** Ortho Sport Victoria, Epworth Health Care, Melbourne, Victoria, Australia, **3** School of Allied Health, Human Services and Sport, La Trobe University, Melbourne, Victoria, Australia

PLOS ONE | https://doi.org/10.1371/journal.pone.0266029 March 24, 2022

Fear of re-injury and **being relaxed about playing sport** were the two most important nodes in the network models that describe the return to sport readiness.

Abnormal knee kinematics after the ACL injury

Clinical Biomechanics 26 (2011) 181–187

Contents lists available at ScienceDirect

Clinical Biomechanics

journal homepage: www.elsevier.com/locate/clinbiomech

Gait adaptation in chronic anterior cruciate ligament-deficient patients: Pivot-shift avoidance gait

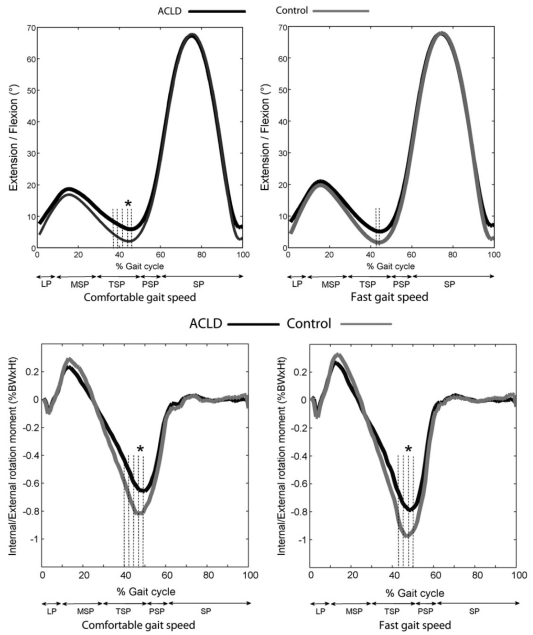
Alexandre Fuentes [a,b,*], Nicola Hagemeister [a,b,c], Pierre Ranger [b,d], Timothy Heron [e], Jacques A. de Guise [a,b,c]

[a] Laboratoire de recherche en imagerie et orthopédie, Centre de recherche du Centre hospitalier de l'Université de Montréal (CRCHUM), Montréal, Canada
[b] Université de Montréal, Faculté de médecine, Montréal, Canada
[c] École de technologie supérieure, Département de génie de la production automatisée, Montréal, Canada
[d] Hôpital du Sacré-Cœur de Montréal, service d'orthopédie, Montréal, Canada
[e] Centre hospitalier de l'Université de Montréal (CHUM), service d'orthopédie, Montréal, Canada



Flexion angle

I/E rotation moment



In terminal stance phase of the gait

✓ Flexion angle ↑

✓ Internal rotation moment ↓

“Pivot-shift avoidance gait”

Similar findings -

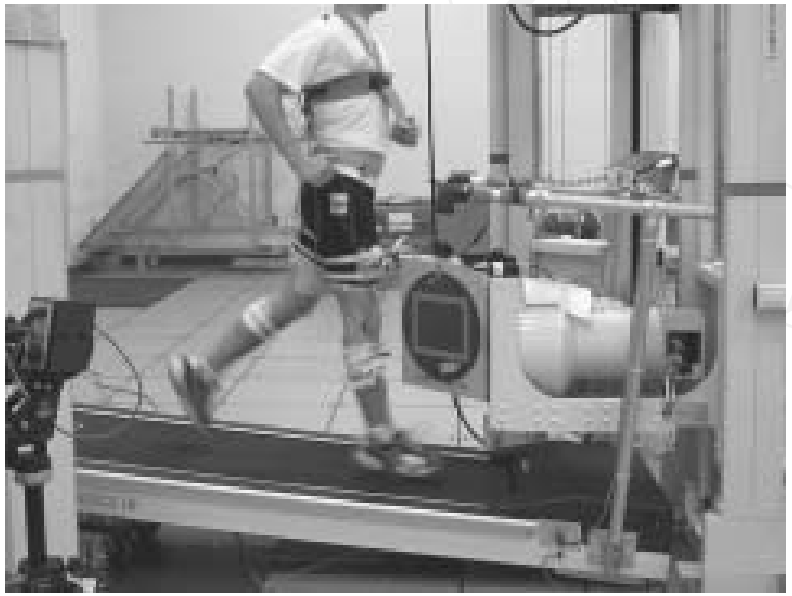
- Gao, B., Zheng, N.N., Clin. Biomech. 2010.
- Hurd, W.J., Snyder-Mackler, L., J.Orthop. Res.2007.

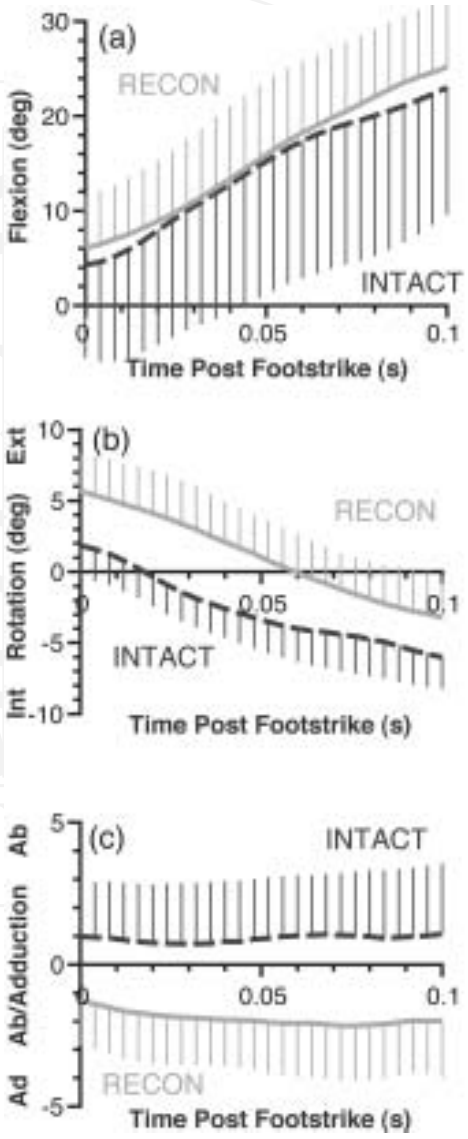
Abnormal knee kinematics even after the ACL reconstruction

Abnormal Rotational Knee Motion During Running After Anterior Cruciate Ligament Reconstruction

Scott Tashman,*† PhD, David Collon,‡ MD, Kyle Anderson,‡ MD, Patricia Kolowich,‡ MD, and William Anderst,† MS
From the †Bone and Joint Center and the ‡Department of Orthopaedic Surgery, Henry Ford Health System, Detroit, Michigan

The American Journal of Sports Medicine, Vol. 32, No. 4
DOI: 10.1177/0363546503261709
© 2004 American Orthopaedic Society for Sports Medicine





At foot strike during downhill running

✓ External rotation ↑

✓ Adduction ↑

Similar findings -

- Papannagari R, et al. Am J Sports Med. 2006.
- Ristanis S, et al. Arthroscopy. 2005

Abnormal knee rotation leads to knee OA

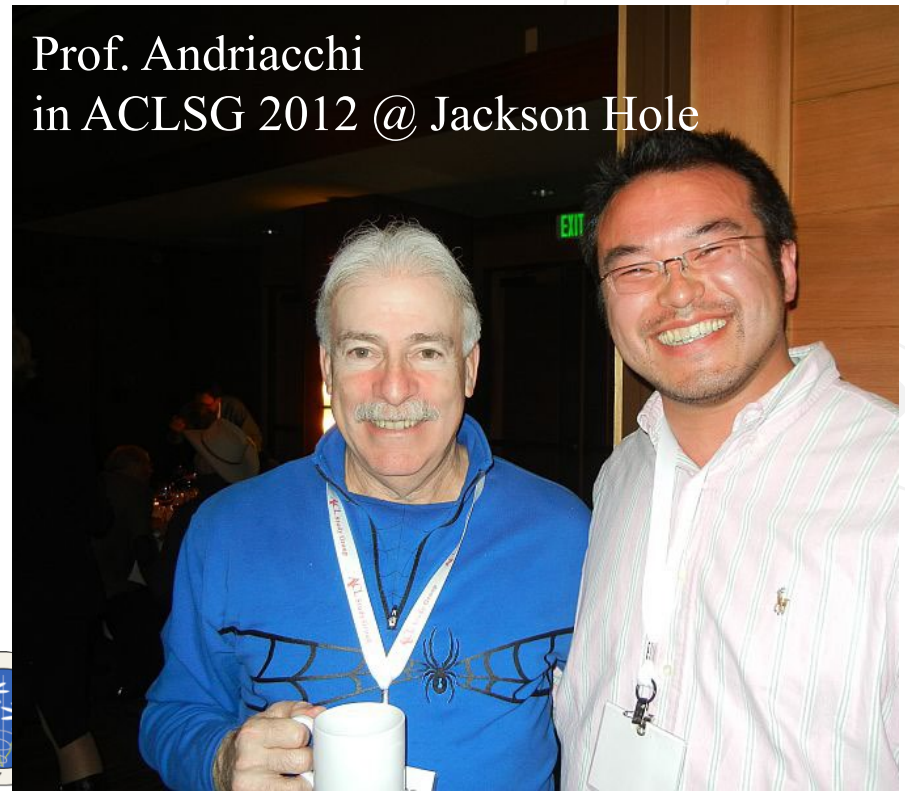
Annals of Biomedical Engineering, Vol. 32, No. 3, March 2004 (©2004) pp. 447–457

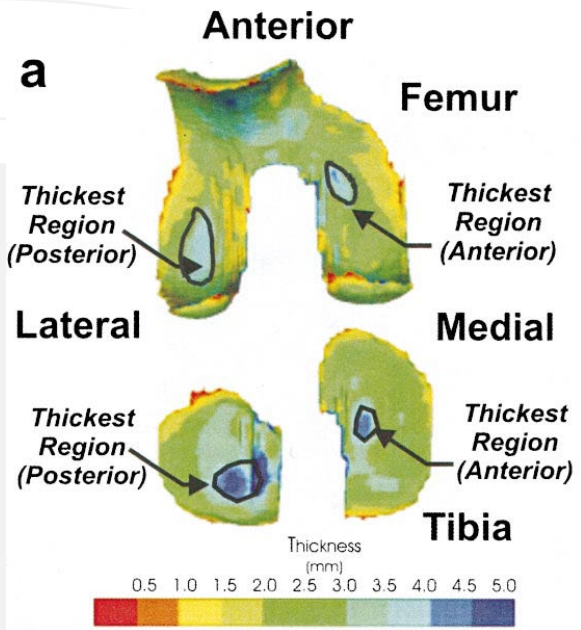
A Framework for the *in Vivo* Pathomechanics of Osteoarthritis at the Knee

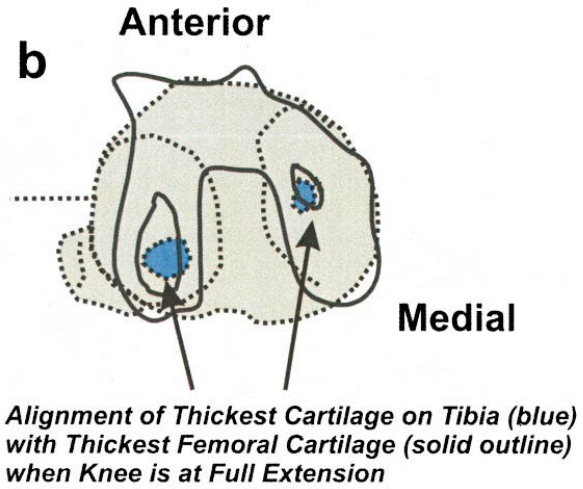
THOMAS P. ANDRIACCHI,[1,2,3] ANNE MÜNDERMANN,[1] R. LANE SMITH,[2,3] EUGENE J. ALEXANDER,[1] CHRIS O. DYRBY,[1] and SEUNGBUM KOO[1]

[1]Department of Mechanical Engineering, Stanford University, Division of Biomechanical Engineering, Stanford, CA; [2]Department of Orthopedics, Stanford, CA; and [3]Palo Alto VA, Bone and Joint Center, Palo Alto, CA

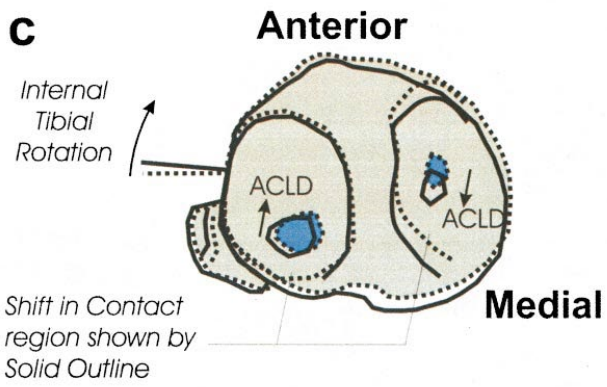
(Received 13 August 2003; accepted 28 October 2003)

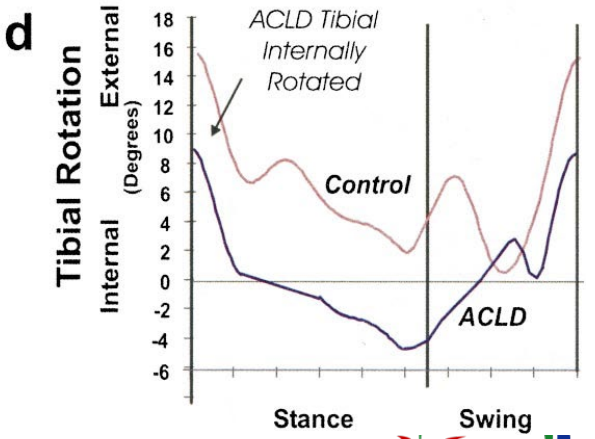






Alignment of Thickest Cartilage on Tibia (blue) with Thickest Femoral Cartilage (solid outline) when Knee is at Full Extension





Pivot-shift induces cartilage / meniscus damage

ELSEVIER

The Knee 5 (1998) 141–158

THE KNEE

Review article

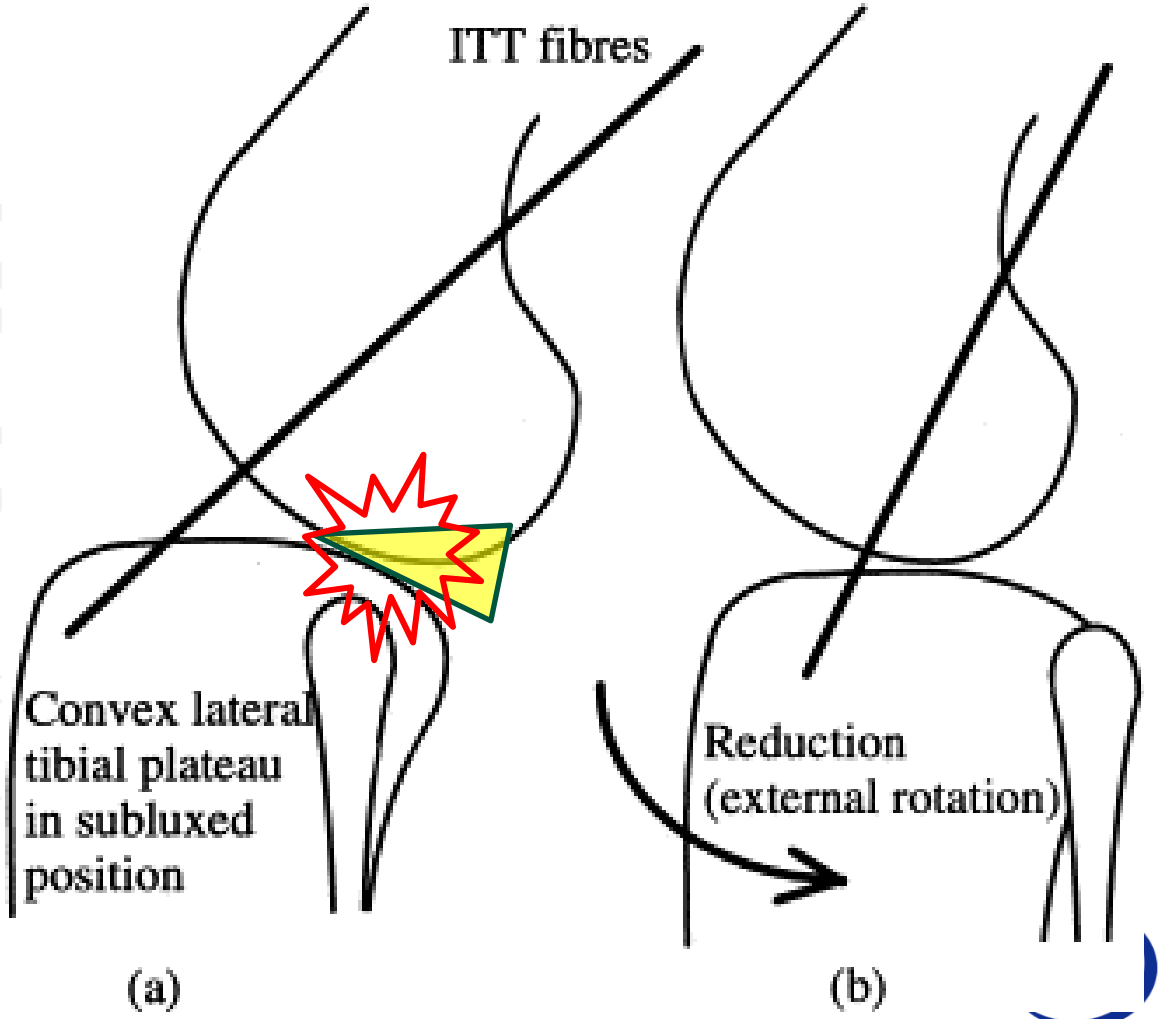
The pivot-shift phenomenon: a clinical and biomechanical perspective

Anthony M.J. Bull*, Andrew A. Amis

Biomechanics Section, Mechanical Engineering Department, Imperial College of Science, Technology and Medicine, Exhibition Road, London SW7 2BX, UK

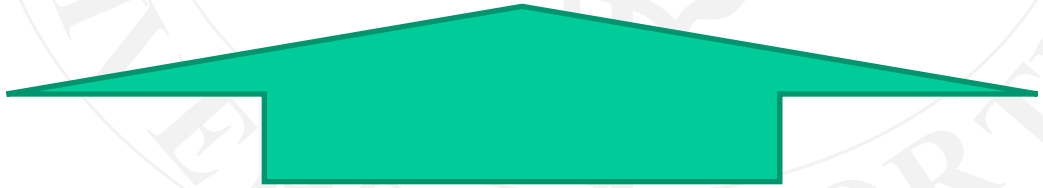






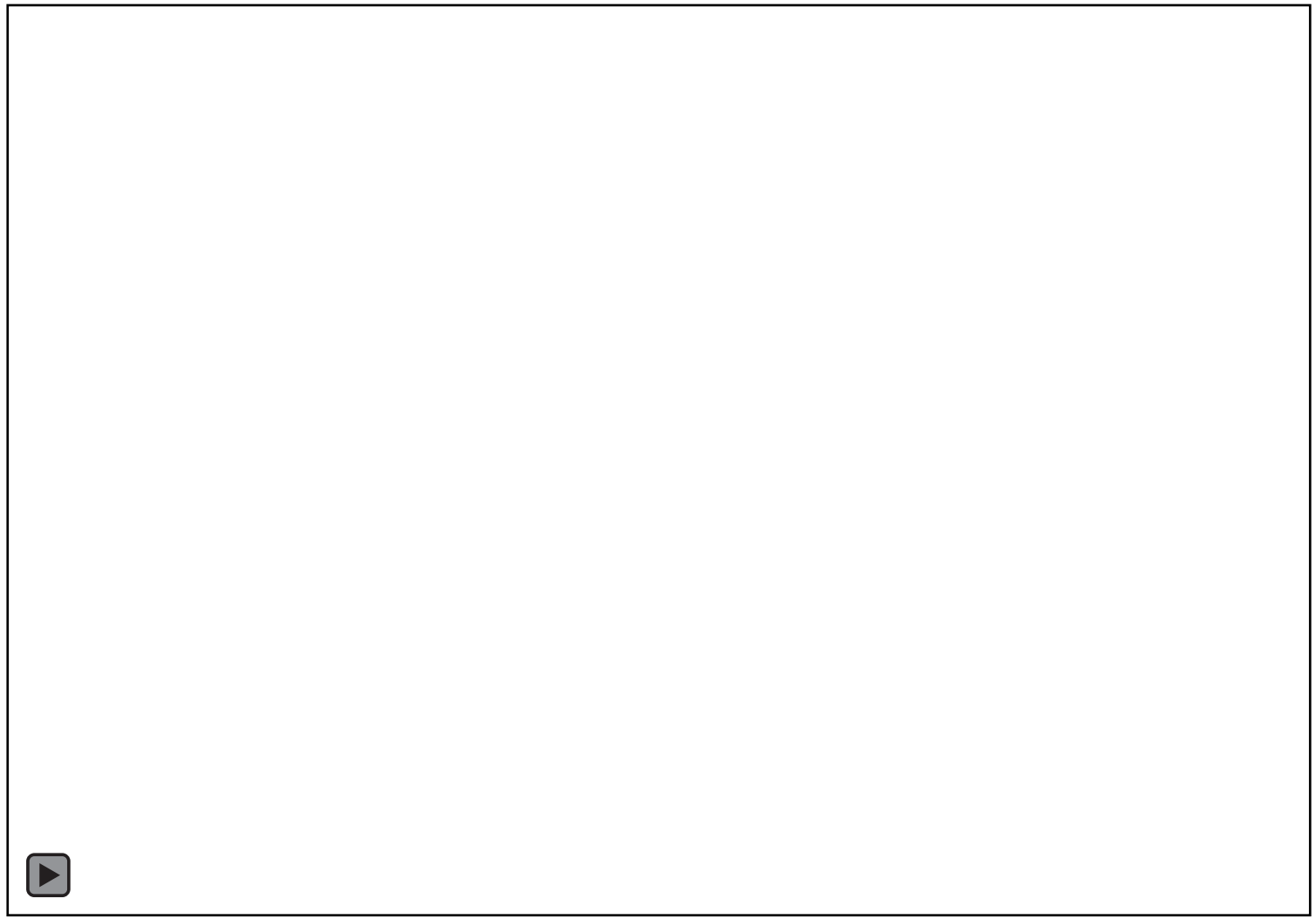
What are the problems after the ACL injury?

1. **Inability to return to sports**
   - instability / fear / pain?
2. **Long term knee osteoarthritis**
   - abnormal knee movement / additional injuries



Pivot-shift

The treatment – ACL reconstruciton

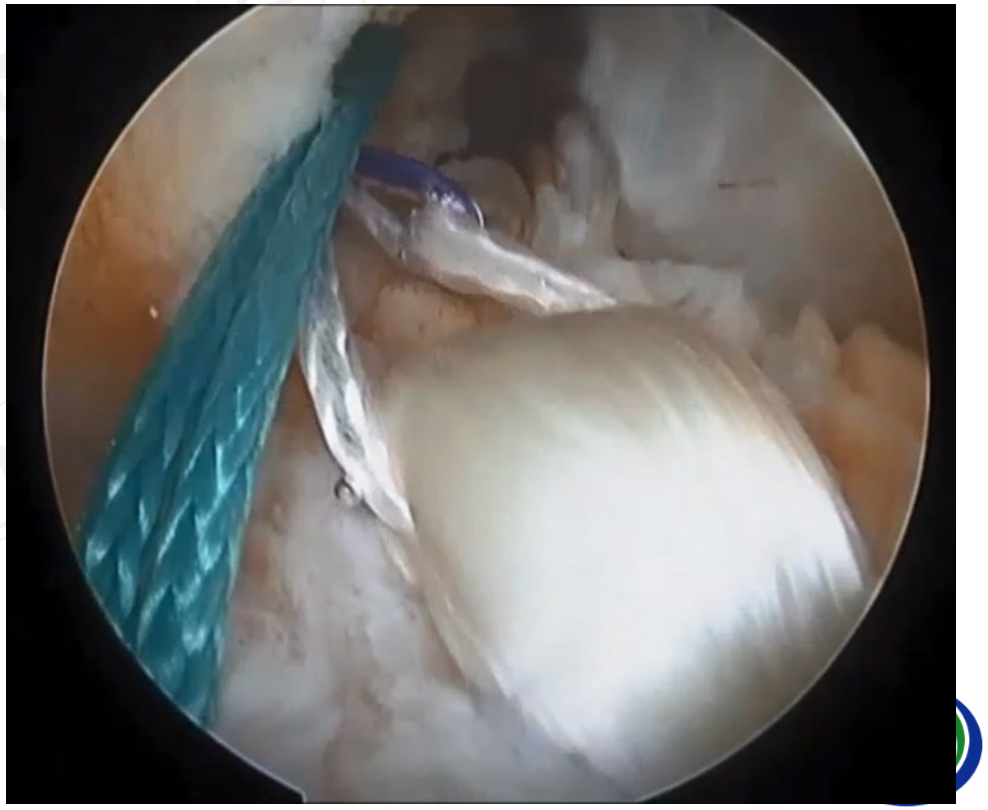


The ultimate goal of the ACL treatment

"**ACL reconstruction** is performed to **eliminate** the pivot-shift."



Dr William Clancy @ Panther Summit 2011



Clinical assessment of the pivot-shift

- **Pivot-shift test**



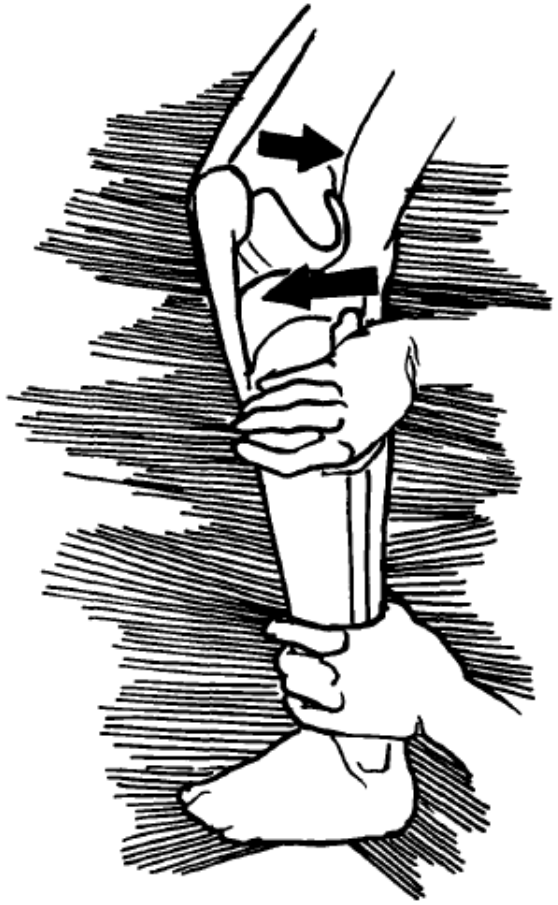


FIG. 4. The "lateral pivot shift test." A sign of anterior cruciate ligament insufficiency.

- Galway et al
Clin Orthop 1980

Pivot-shift test is clinically important



Less - Subjective knee function

- Kocher et al AJSM 2004, Leitze et al Clin Orthop 2005, Ayeni et al KSSTA 2012

Pivot-shift test

positive

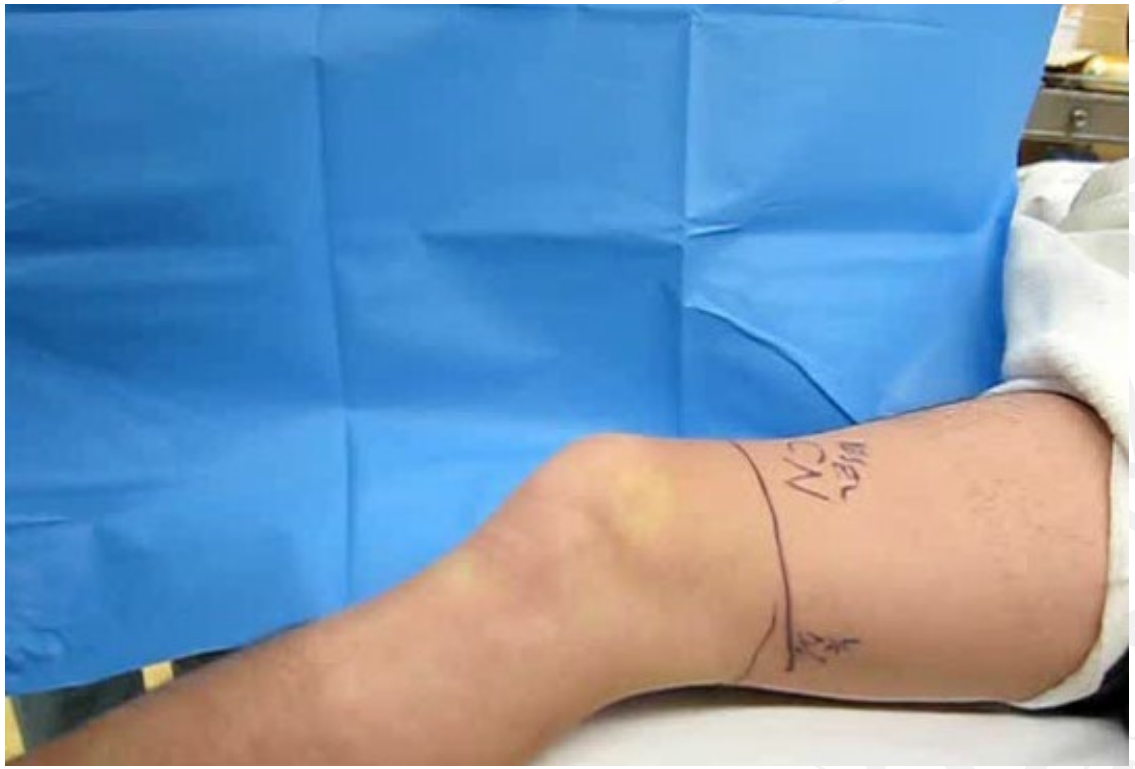


More - Degenerative change

- Jonsson H et al, Acta Orthop Scand 2004, Leitze Z et al, Clin Orthop 2005

Limitations of clinical pivot-shift test

➢ Pivot-shift test



《 IKDC form 》

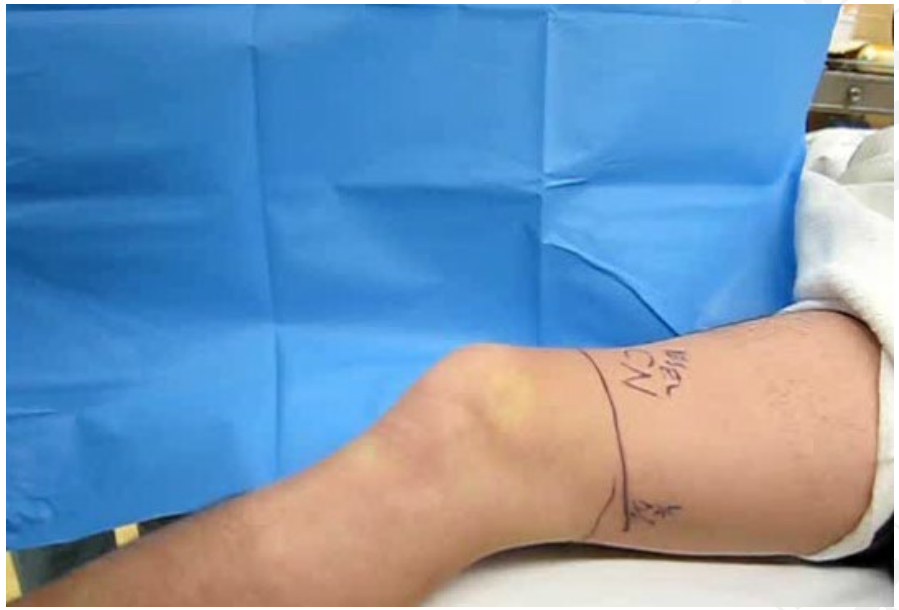
Grade	
0 (absence)	··· Negative
1 (glide)	Positive
2 (clunk)	
3 (gross)	

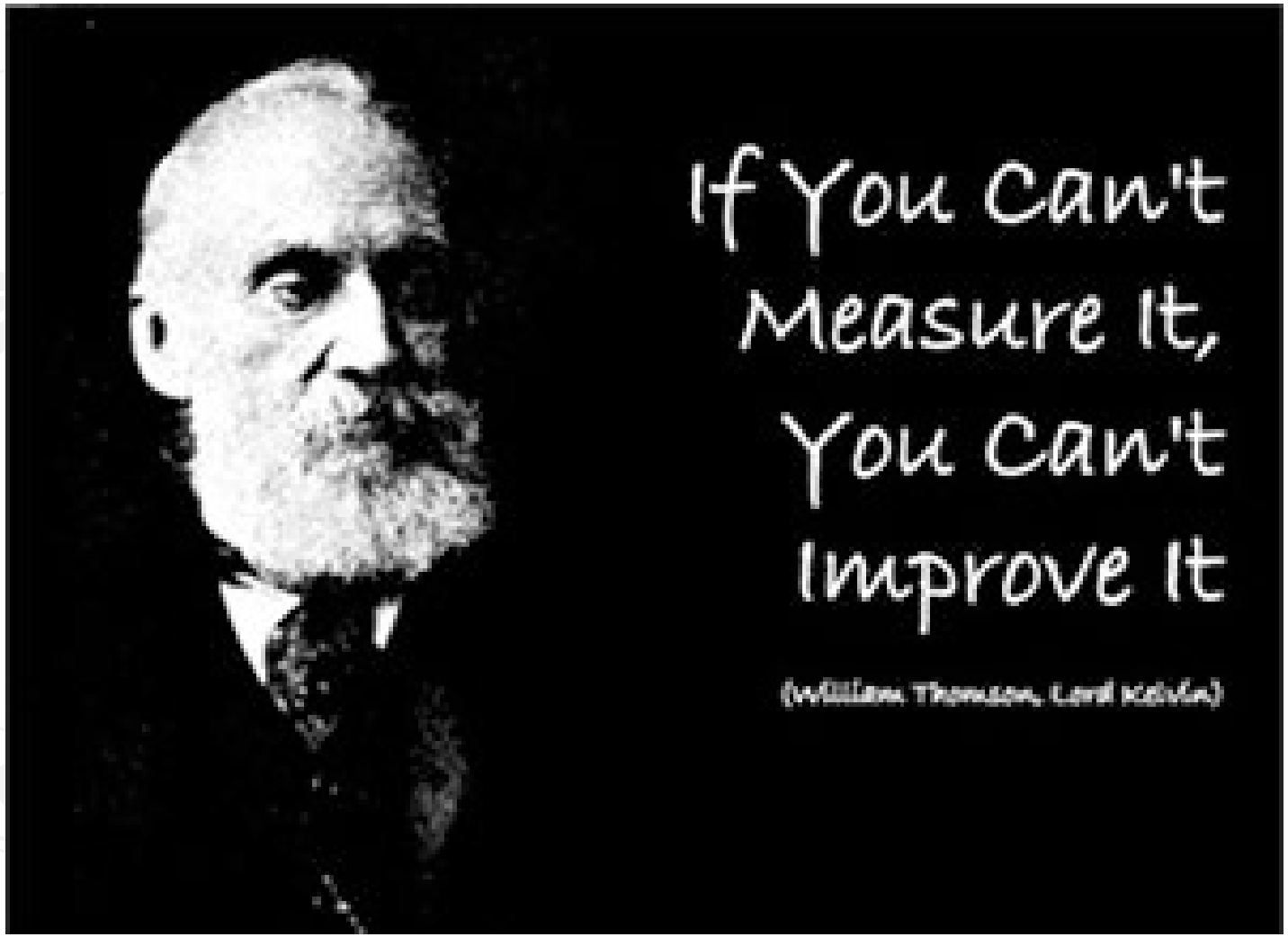
- Evaluating **the magnitude** of the pivot-shift

➢ **Subjective + only 4 grade!!**

How about “measurement” of the pivot-shift??

How big is this??





William Thomson, “the Lord Kelvin” (1824-1907)
- Pioneer of physics and thermodynamics -

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Pivot-shift measurement

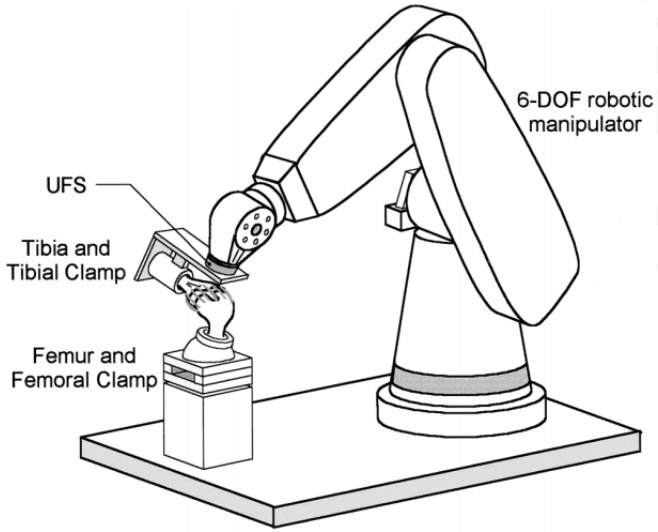
KOBE UNIVERSITY ORTHOPAEDICS

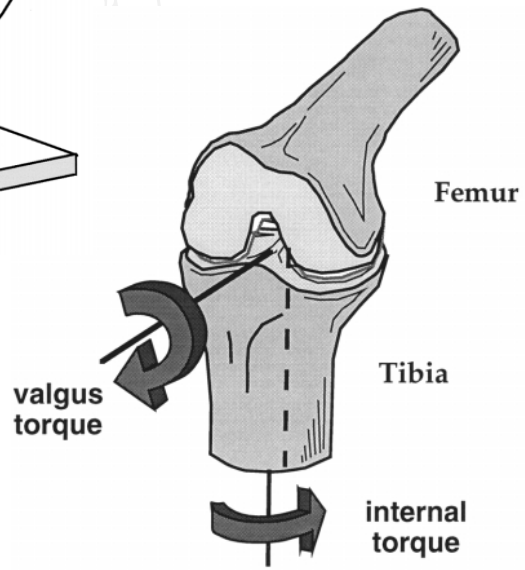
KOBE UNIVERSITY

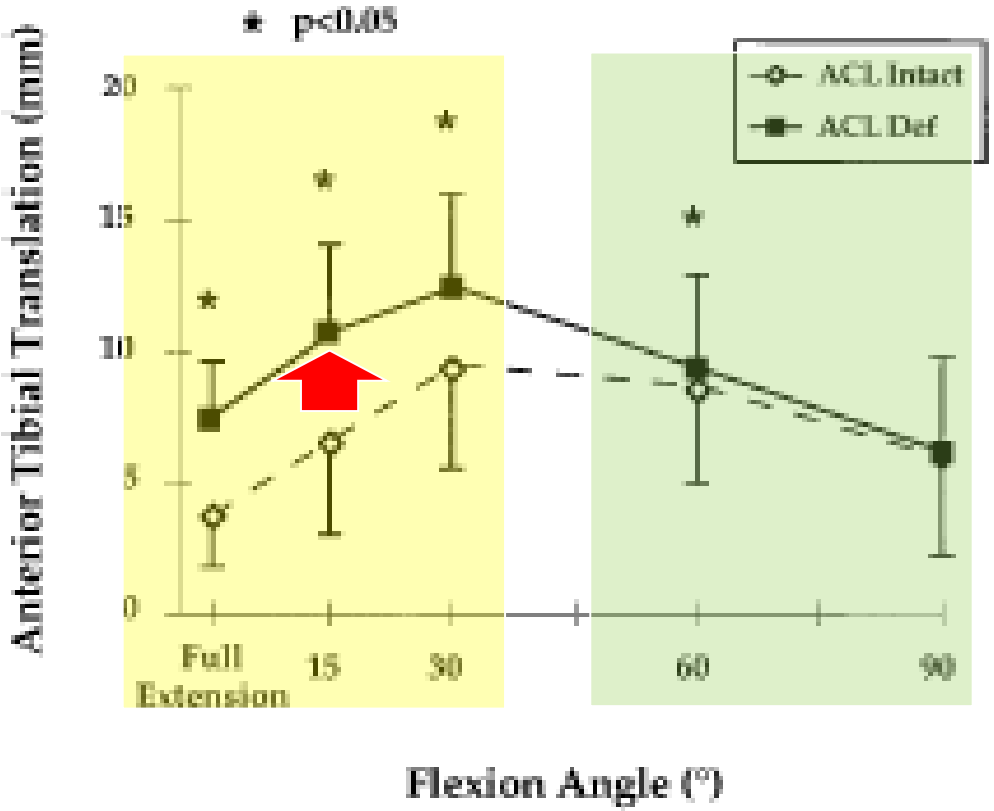
In vitro biomechanical research for the pivot-shift

Coupled anterior tibial translation (mm)

- Combined rotatory loading (valgus + IR) makes the tibial anterior translation.







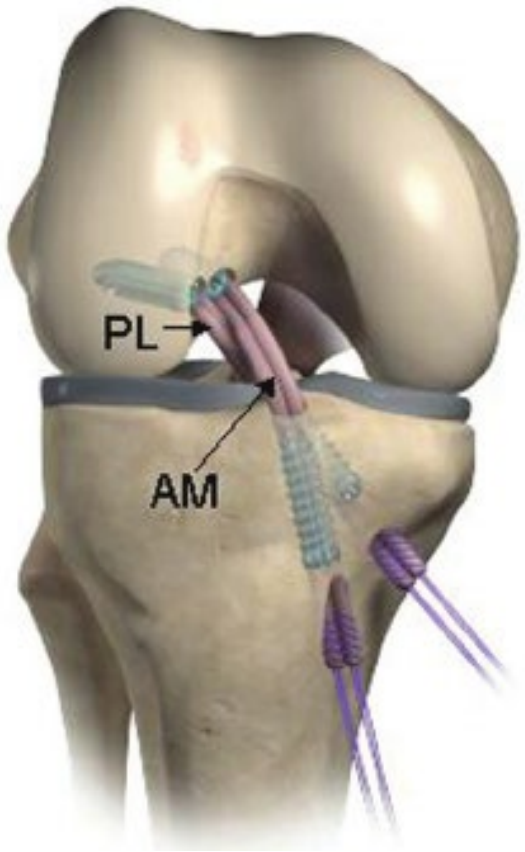
Kanamori A, et al. Arthroscopy 2000

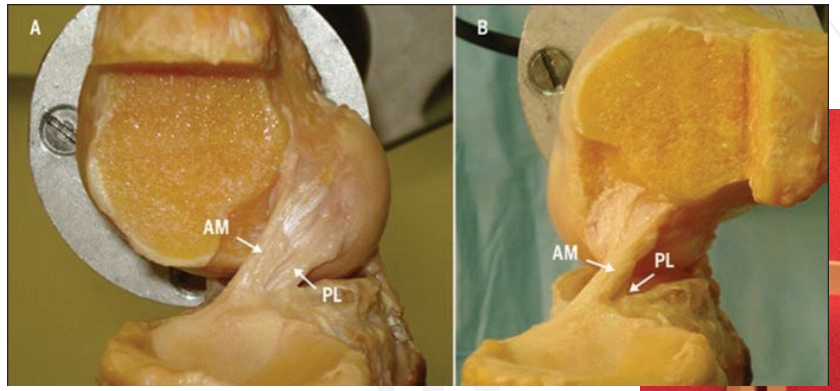
Arthroscopy. 2005 Oct;21(10):1275. doi: 10.1016/j.arthro.2005.07.018.

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Arthroscopic double-bundle anterior cruciate ligament reconstruction: an anatomic approach

Peter S Cha [1], Peter U Brucker, Robin V West, Boris A Zelle, Masayoshi Yagi, Masahiro Kurosaka, Freddie H Fu







In vitro biomechanical study: DB vs SB

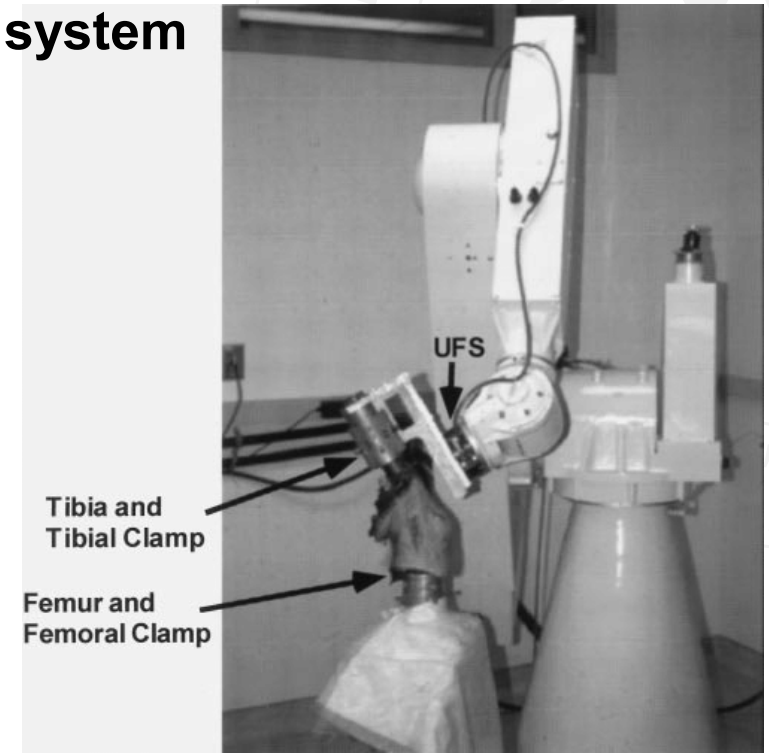
The American Journal of Sports Medicine
http://ajs.sagepub.com/
2002 30: 660

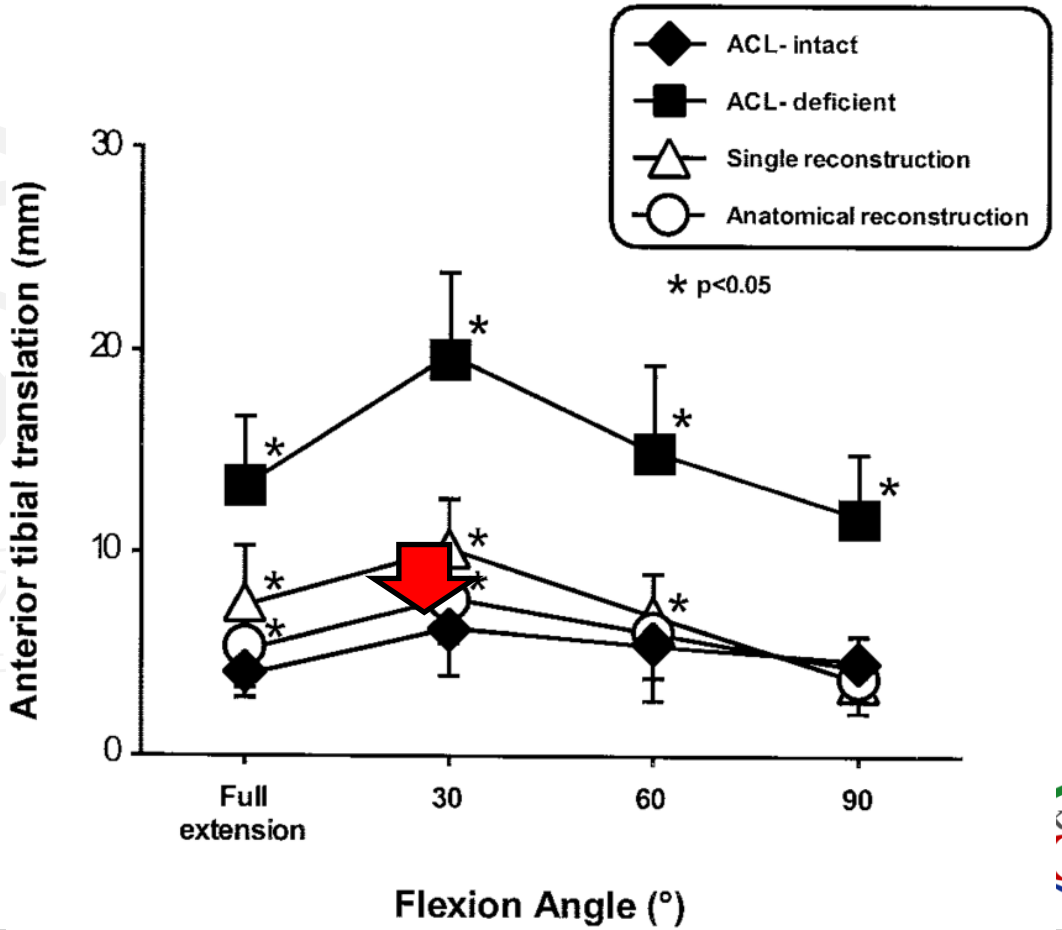
Biomechanical Analysis of an Anatomic Anterior Cruciate Ligament Reconstruction

Masayoshi Yagi, MD, Eric K. Wong, MS, Akihiro Kanamori, MD, Richard E. Debski, PhD, Freddie H. Fu, MD, and Savio L-Y. Woo,* PhD

From the Musculoskeletal Research Center, Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, Pennsylvania

- **Simulated pivot-shift**
  by robotic system





1st in-vivo measurement of the pivot-shift

Intraoperative measurement of knee kinematics in reconstruction of the anterior cruciate ligament

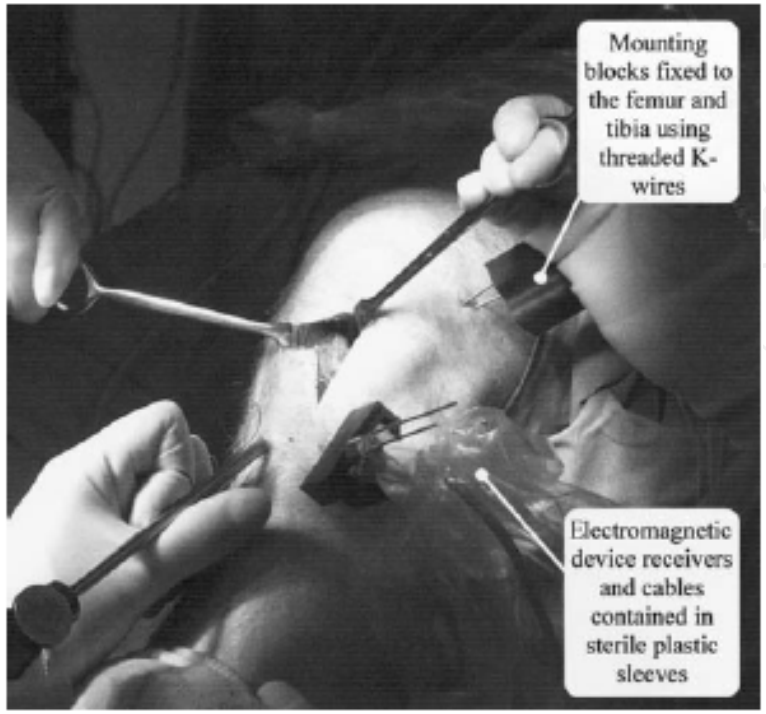
A. M. J. Bull, P. H. Earnshaw, A. Smith, M. V. Katchburian, A. N. A. Hassan, A. A. Amis

From Imperial College, and Guy's and St Thomas' Hospital NHS Trust, London, England

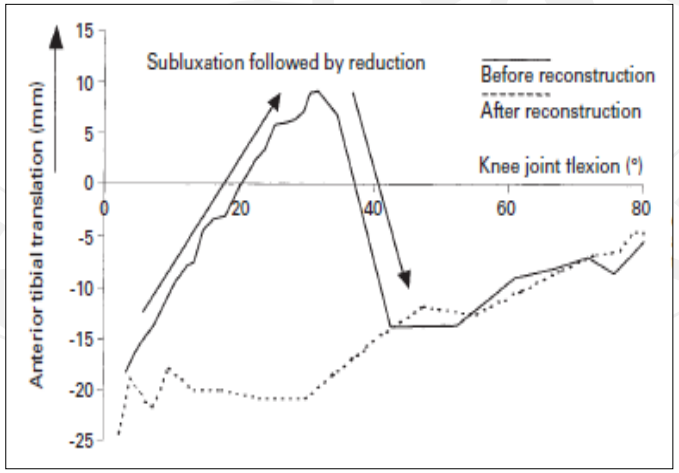
J Bone Joint Surg Br. 2002 Sep;84(7):1075-81.

Electromagnetic sensor
（Flock of birds）

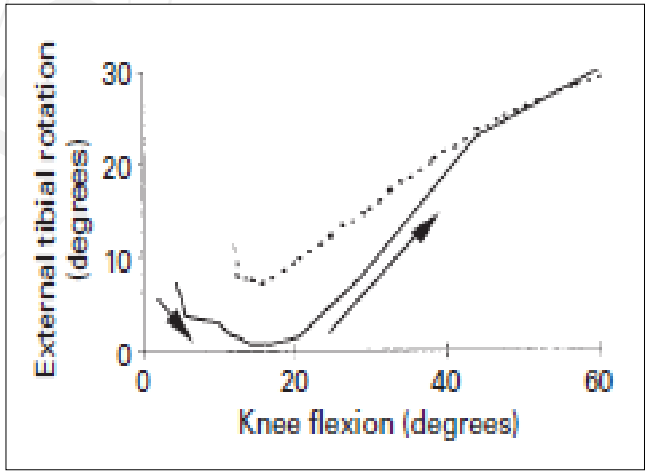




AP translation



E/I rotation



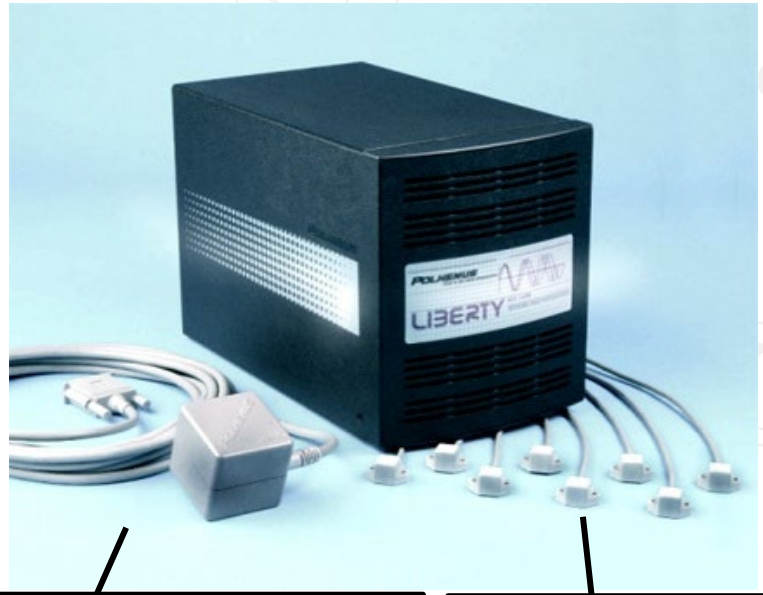
➢ **Consistent wave in AP translation**

Electromagnetic sensor

POLHEMUS
INNOVATION IN MOTION™

LIBERTY

THE HIGH-SPEED INDUSTRY LEADER FOR ACCURATE MOTION TRACKING



Transmitter

Receivers

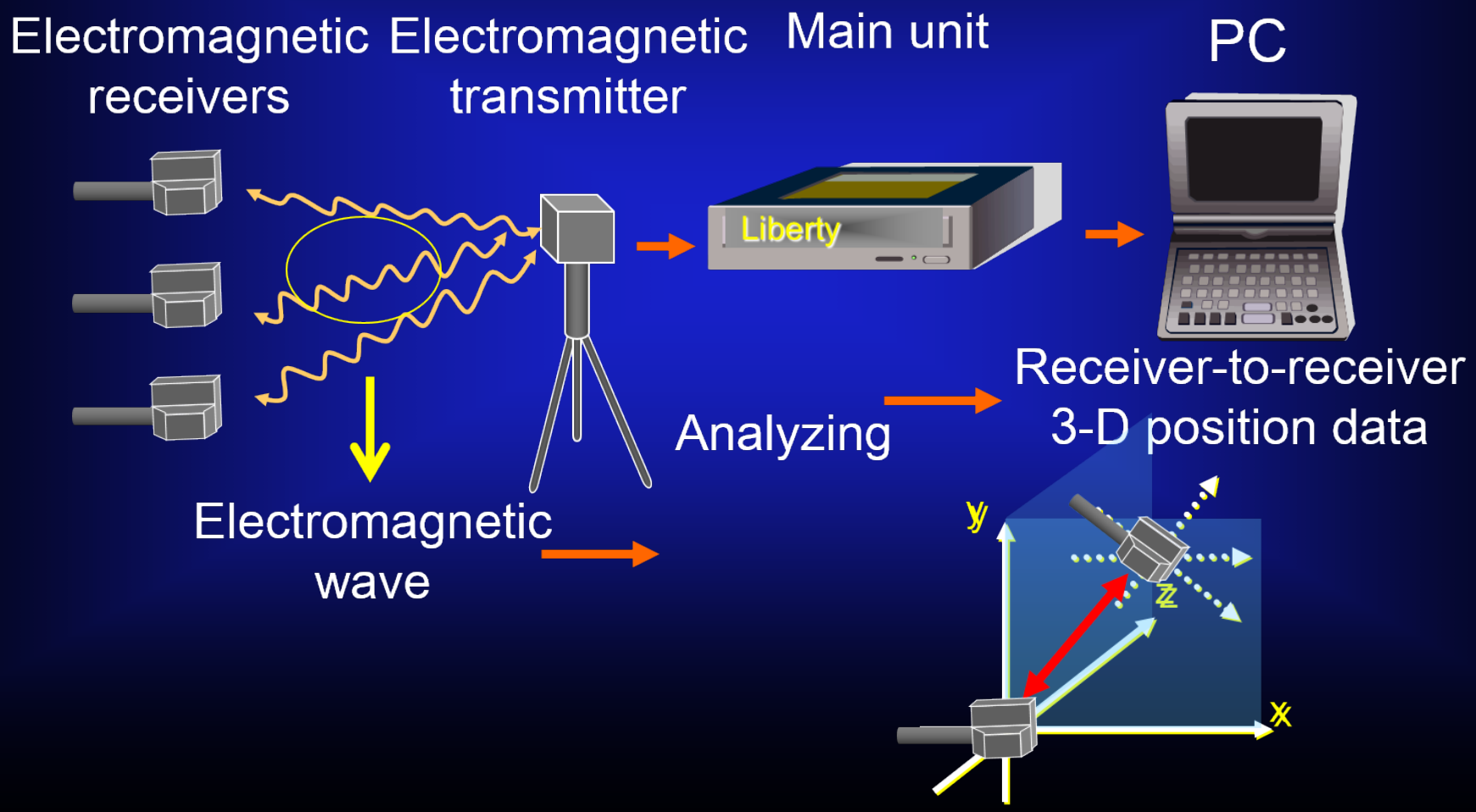
LIBERTY AT A GLANCE

	# OF SENSORS	UPDATE RATE (HZ)
6 DOF POSITION & ORIENTATION	4 ON BASE (UP TO 16)	240 PER SENSOR
EMBEDDABLE SOURCES & SENSORS	LATENCY	WIRED | WIRELESS
NO LINE-OF-SIGHT REQUIREMENTS	3.5 MILLISECONDS	WIRED

Electromagnetic tracking device

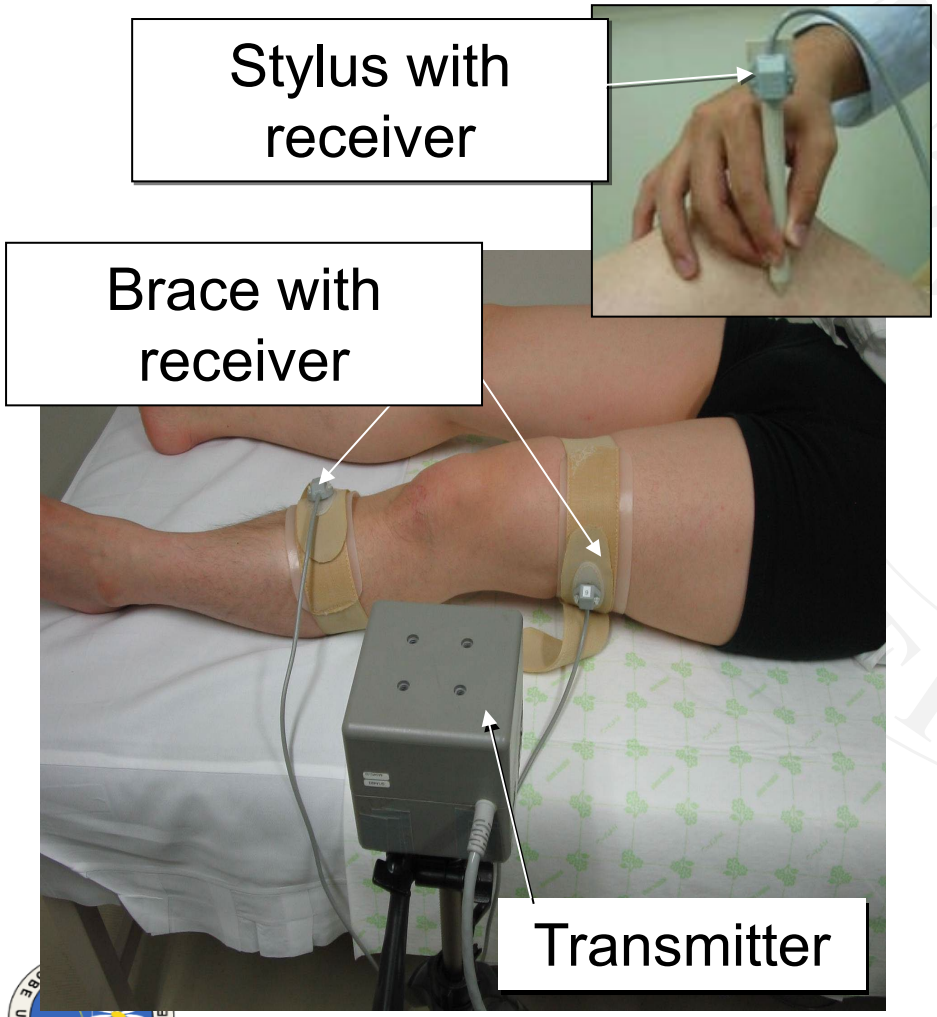
LIBERTY (Polhemus,Vermont)

Personal computer

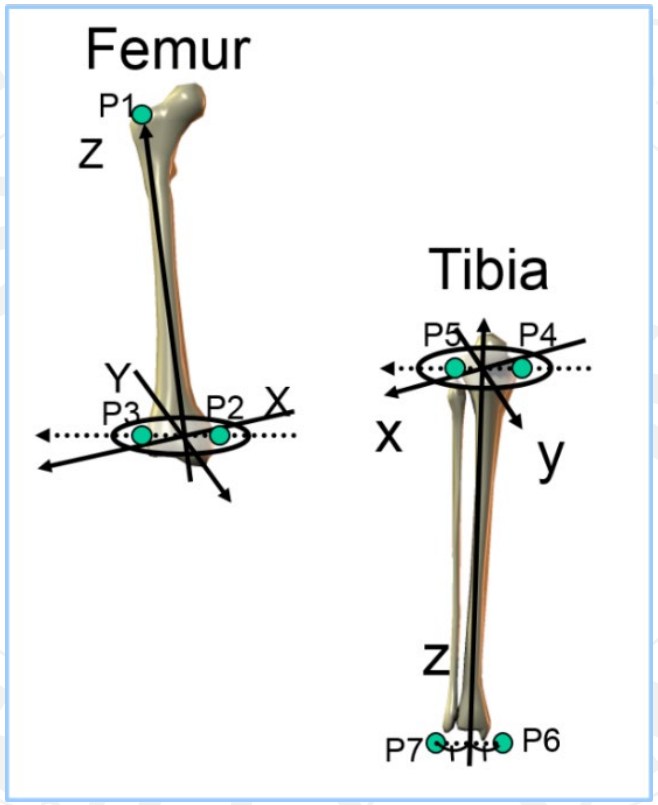


Non-invasive application of the electromagnetic system

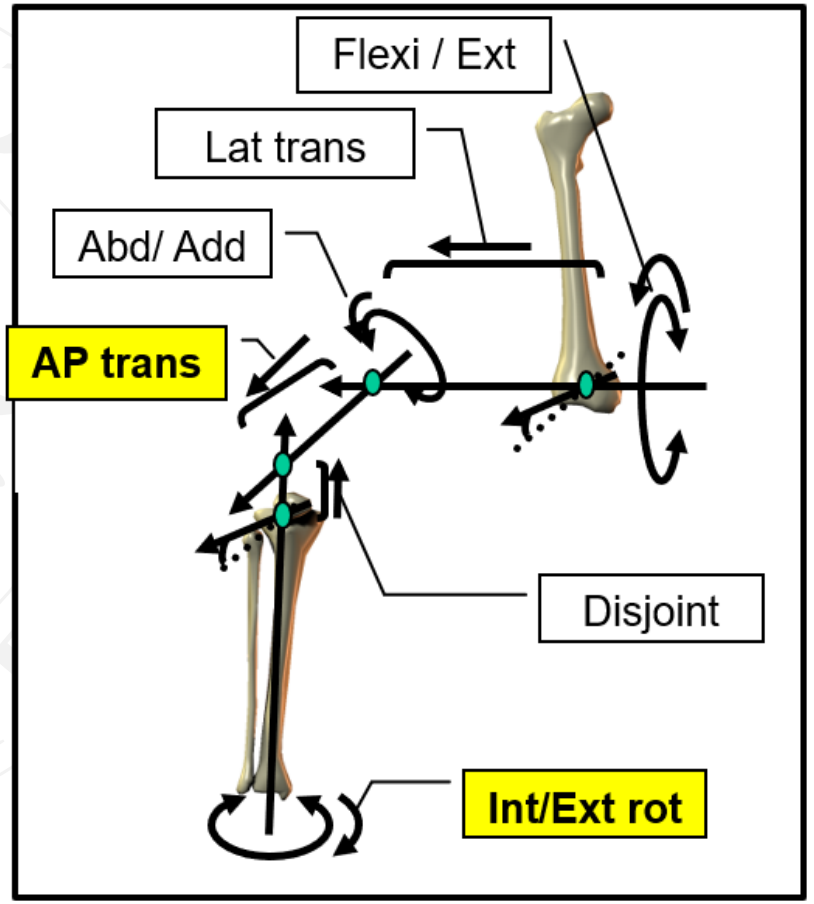
Experimental set-up



Coordinate system

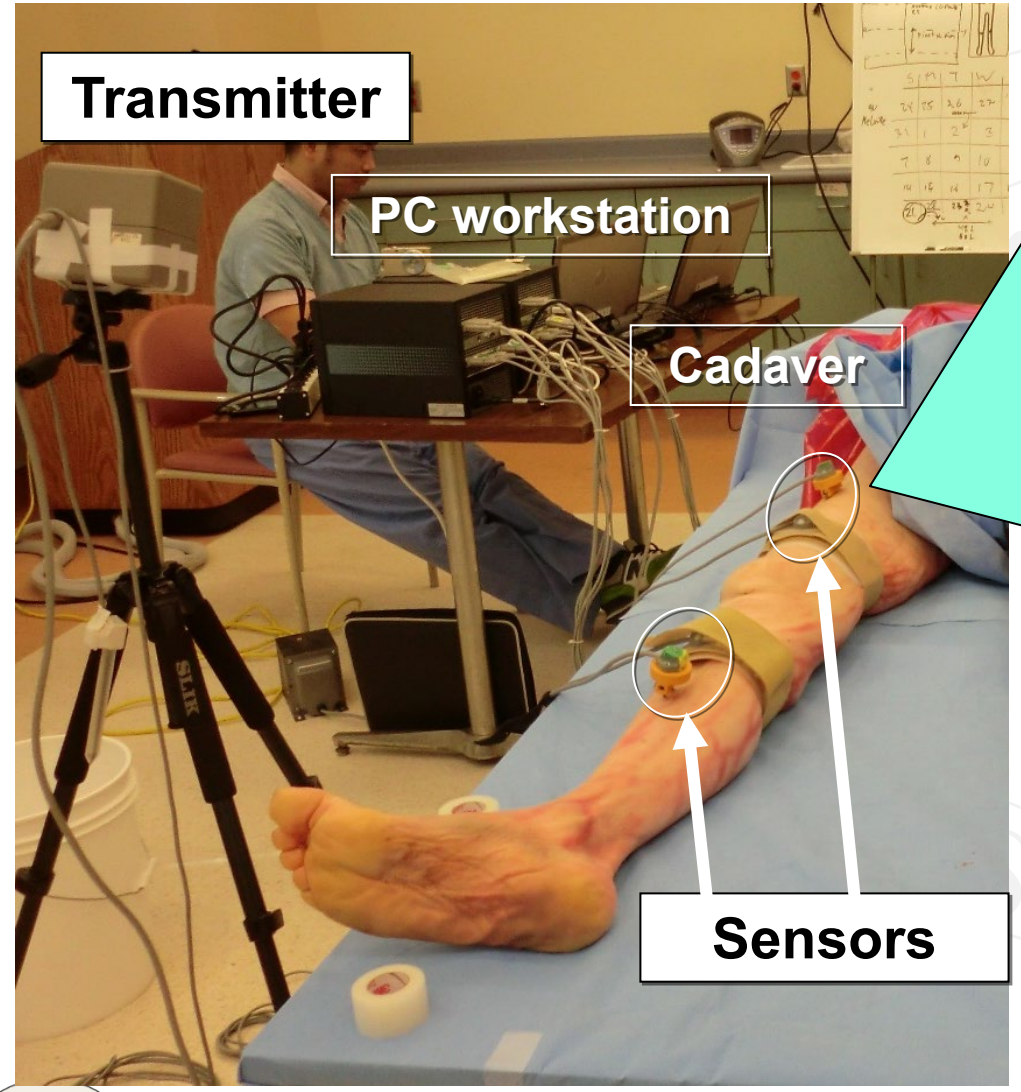


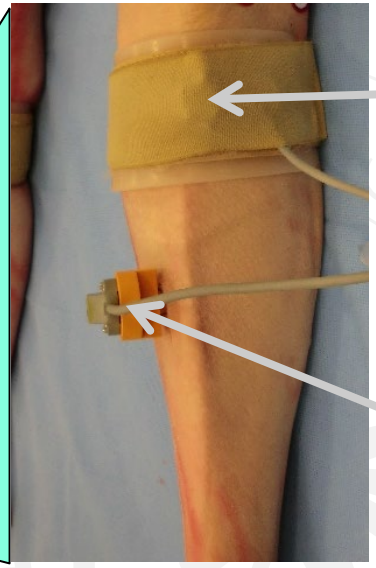
6degree-of-freedom



Grood ES, et al. J Biomech Eng 105:136-144, 1983

Validation of the electromagnetic system





Sensors on brace

(non-invasive)

Sensors fixed with pins
(invasive)



Measurement accuracy

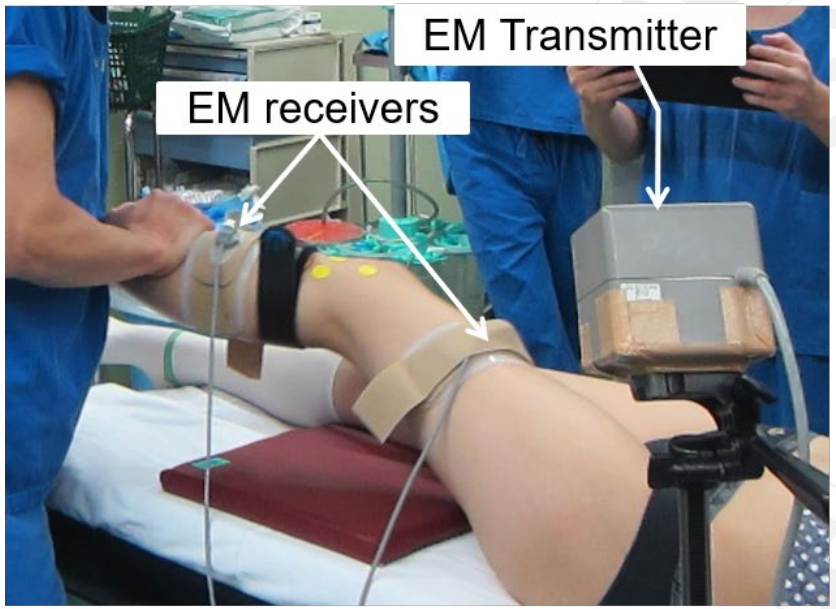
AP trans - 0.85mm

Varus/Valgus-0.62°

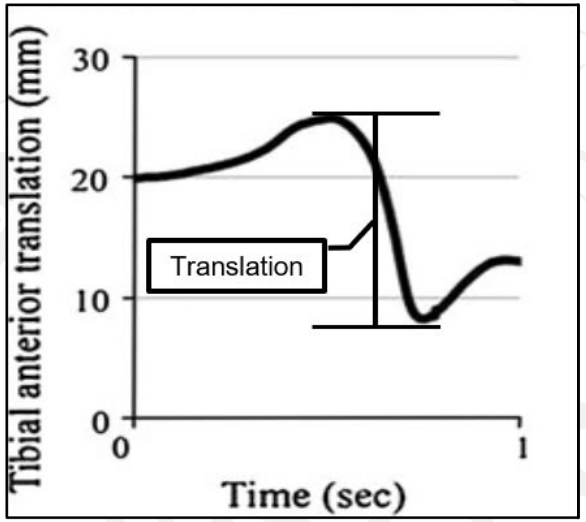
I/E rotation- 1.92°

Nagamune K, et al

Clinical measurements of the pivot-shift

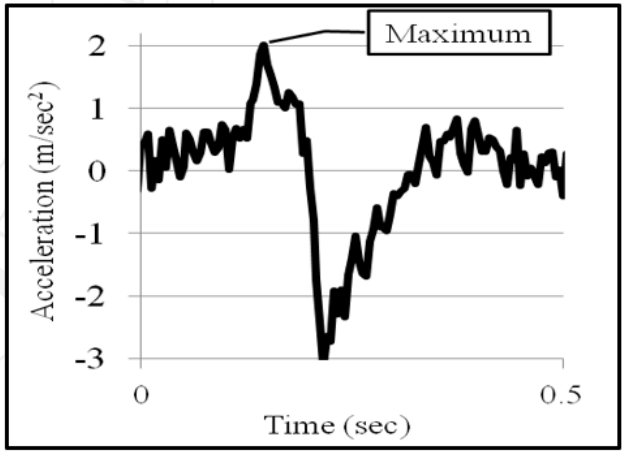


Tibial translation



Calculation

Tibial acceleration



Provide instant 6DOF

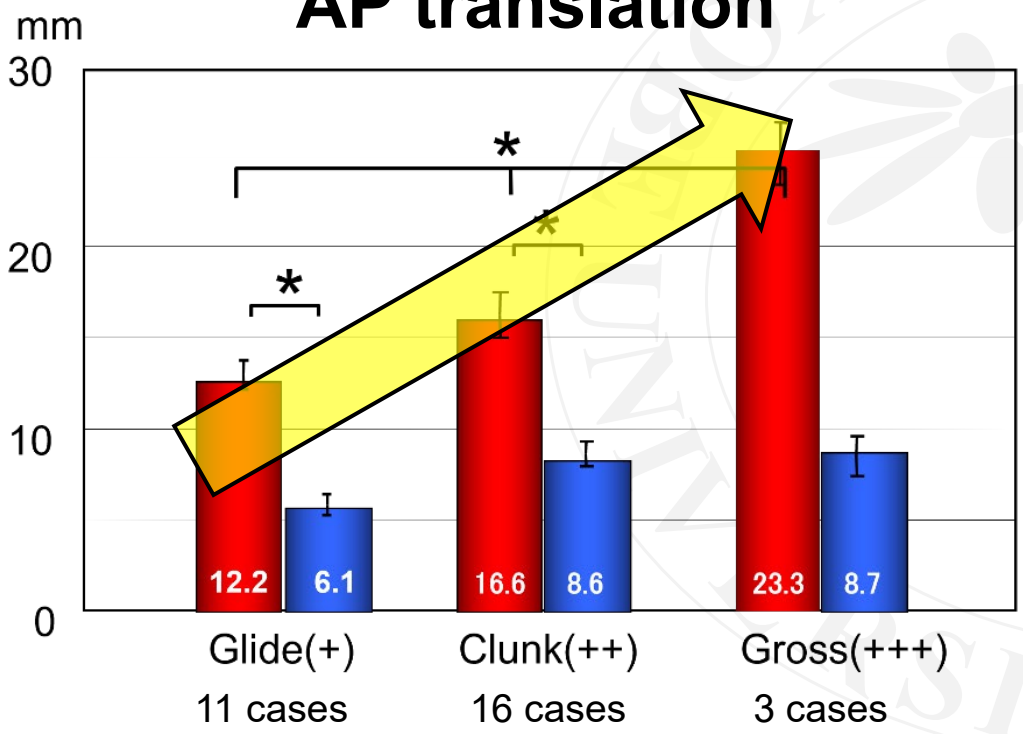
Hoshino et al. , AJSM. 2007, Araki et al, Int Orthop. 2011, Nagai et al, KSSTA 2015, Miyaji et al KSSTA 2019

In vivo pivot-shift measurements vs manual test

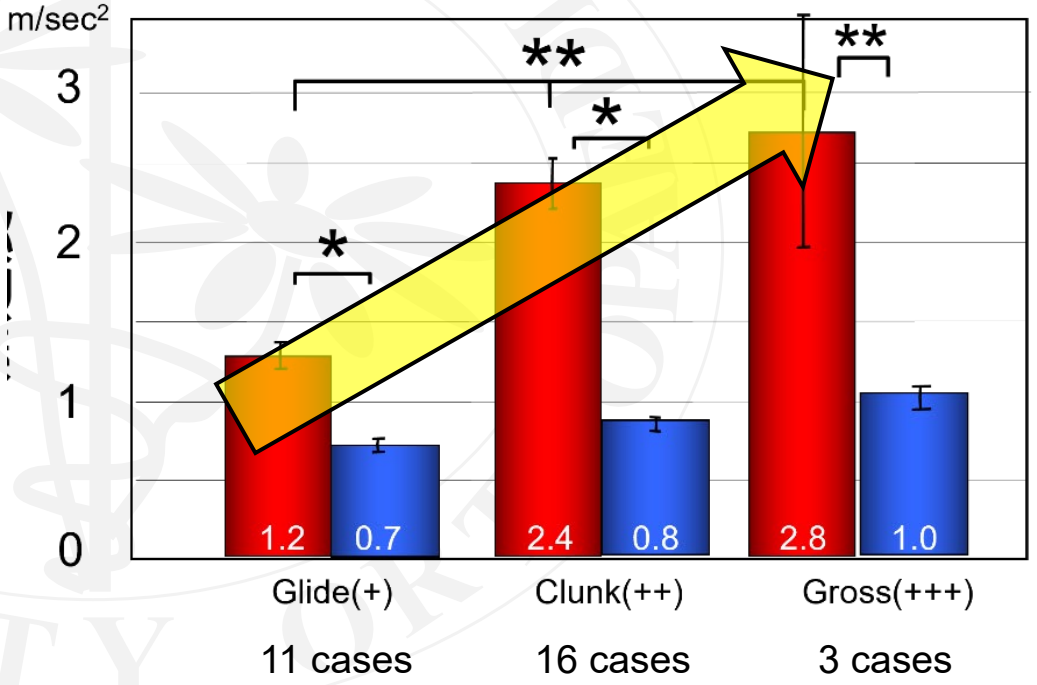
30 ACL injury cases

ACL injured | Intact

AP translation



Acceleration



(mean ±SE)

* ; $p < 0.001$

** ; $p < 0.05$

Hoshino Y, et al. Am J Sport Med 2007

➢ **Measurements ∝ Manual grading**

Clinical studies using pivot-shift measurement

✓ A… Orthop 2007

✓ M… sh… Orthop 2011

✓ … SSTA 2019

✓ … SSTA 2020

✓ … SSTA 2019

✓ Th… in… SSTA 2020

✓ … SSTA 2022

Knee Surgery, Sports Traumatology, Arthroscopy (2022) 30:3508–3514
https://doi.org/10.1007/s00167-022-06970-z

KNEE

Check for updates

The coronal lateral collateral ligament sign in the anterior cruciate ligament-injured knees was observed regardless of the knee laxity based on the quantitative measurements

Chih-Kai Hong[1] · Yuichi Hoshino[2] · Shu Watanabe[2] · Kanto Nagai[2] · Takehiko Matsushita[2] · Wei-Ren Su[1,3,4] · Ryosuke Kuroda[2]

Received: 3 December 2021 / Accepted: 29 March 2022 / Published online: 12 April 2022
© The Author(s) under exclusive licence to European Society of Sports Traumatology, Knee Surgery, Arthroscopy (ESSKA) 2022

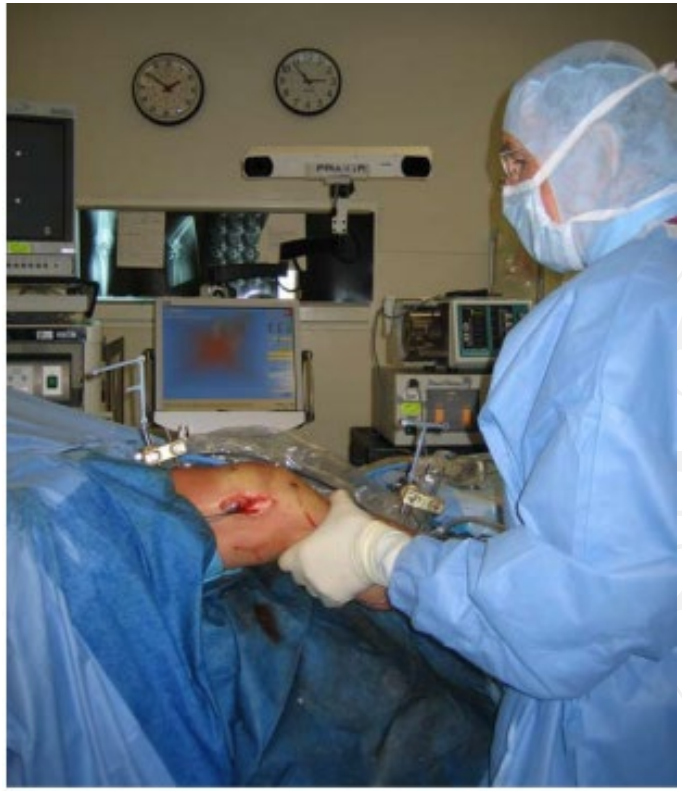
Unrepaired lateral meniscus tears lead to remaining pivot-shift in ACL-reconstructed knees

Yuichi Hoshino[1] · Yuji Hiroshima[1] · Nobuaki Miyaji[1] · Kanto Nagai[1] · Daisuke Araki[1] · Noriyuki Kanzaki[1] · Kenichiro Kakutani[1] · Takehiko Matsushita[1] · Ryosuke Kuroda[1]

Received: 6 January 2020 / Accepted: 16 April 2020

Other types of pivot-shift measurement

Other pivot-shift measurement devices



Colombet P, et al. Clin Orthop. 2007



Lopomo N, et al. KSSTA. 2012



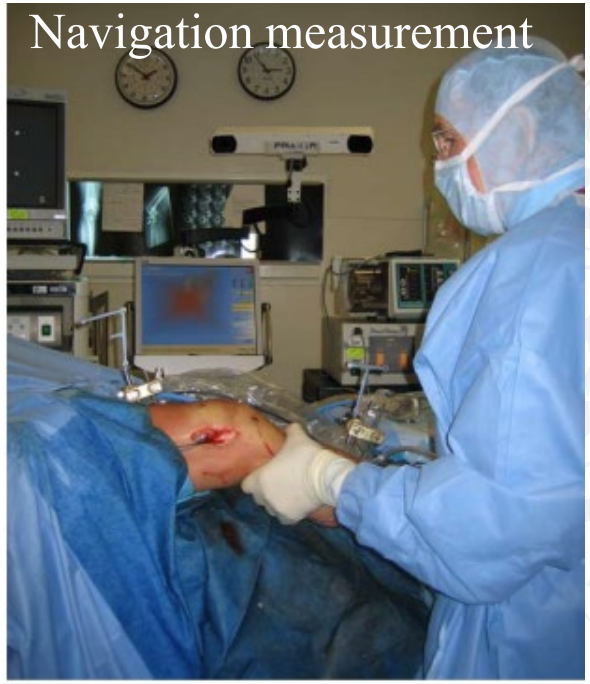
Hoshino Y, et al. KSSTA. 2012

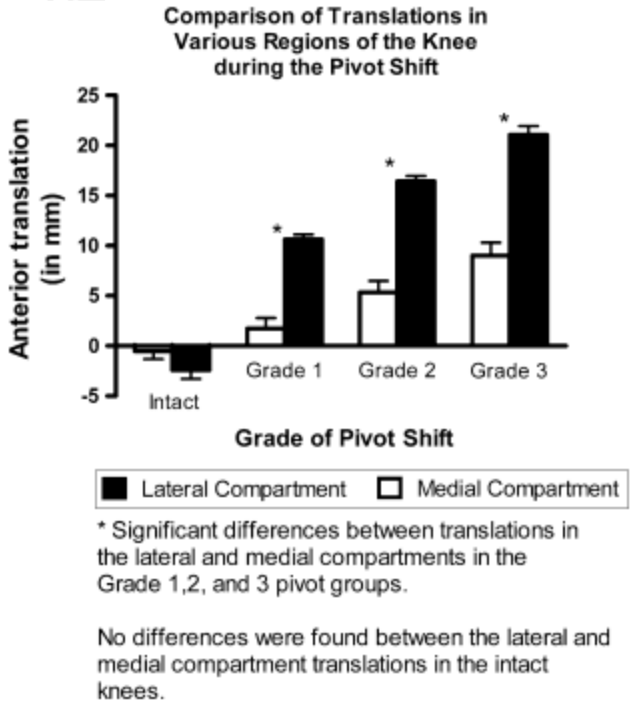


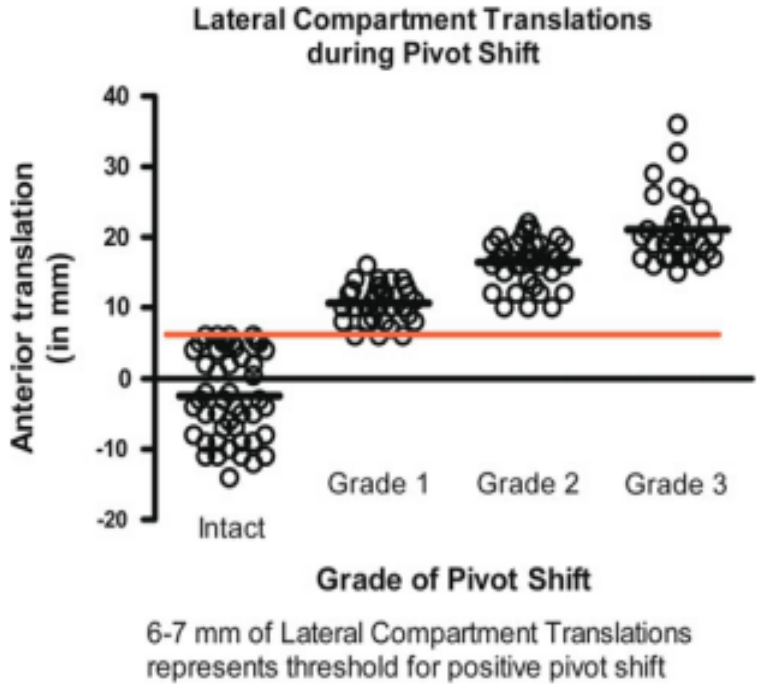
Hoshino Y, et al. KSSTA. 2012

Features of other pivot-shift measurements

1. Navigation – compartmental tibial translation







-Bedi et al KSSTA 2010

➢ ***Lateral compartment translation – more sensitive***

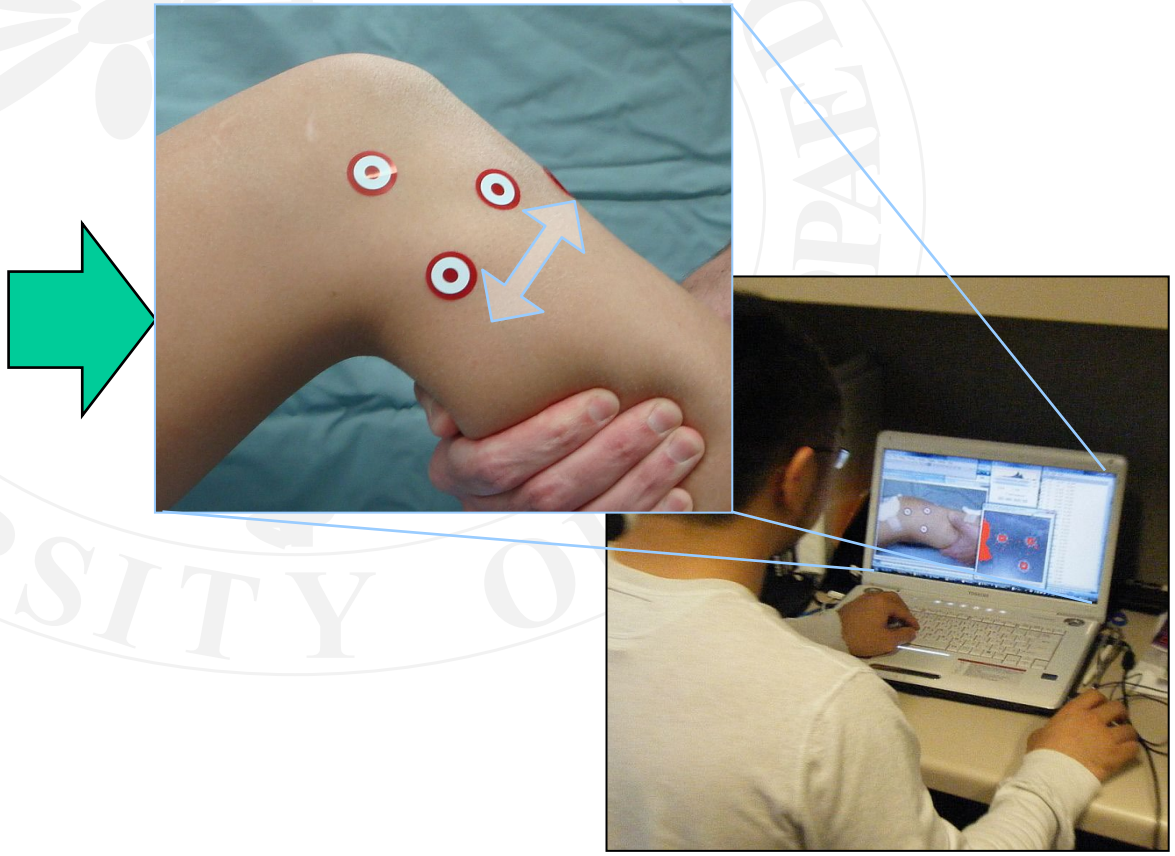
Features of other pivot-shift measurements

2. Pivot-shift image analysis - affordable

Taking a movie during the test



Image analysis on PC



Hoshino Y, et al. KSSTA 2012

Image analysis evaluation of pivot-shift

Measurement scheme for lateral tibial translation

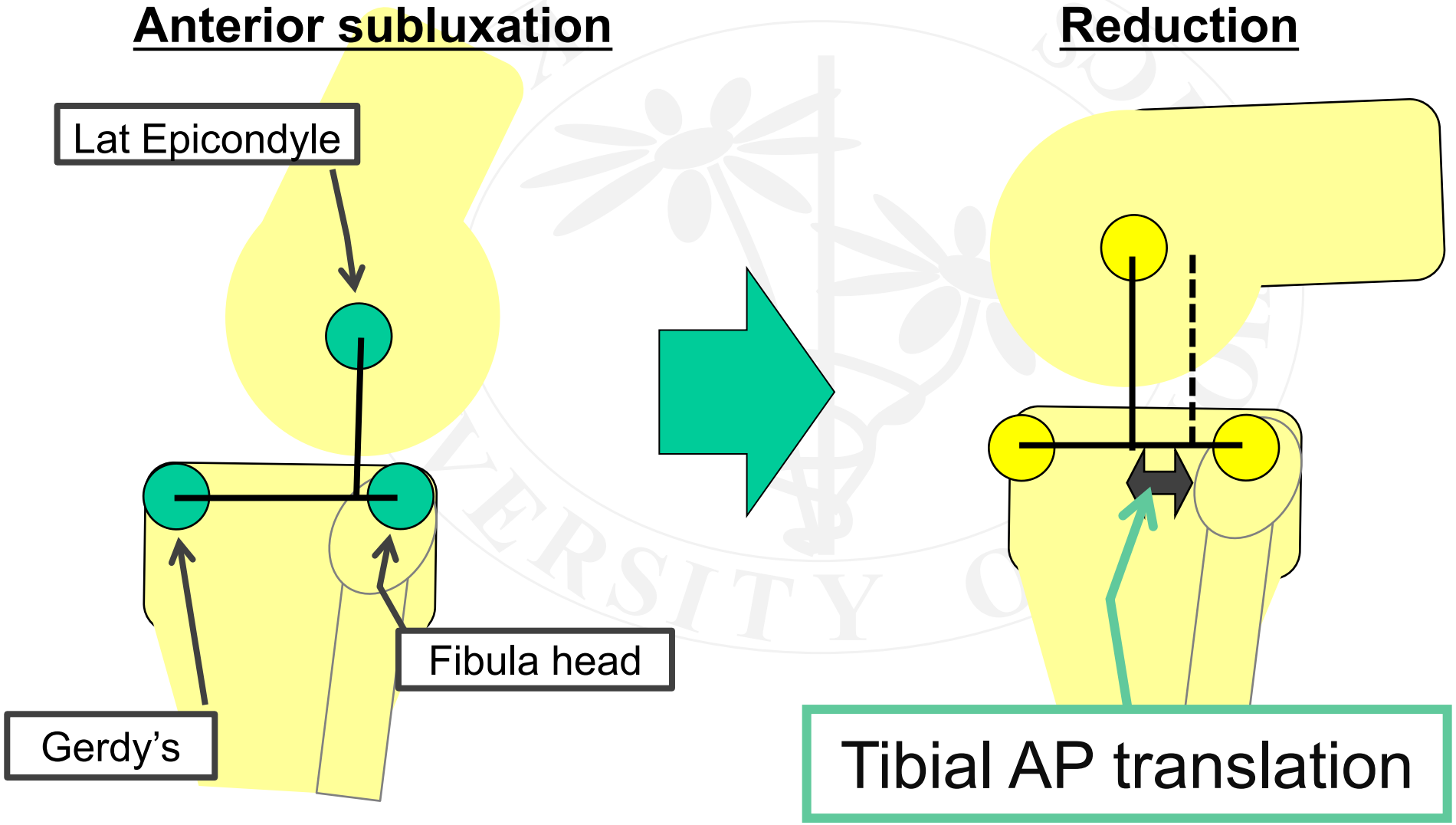
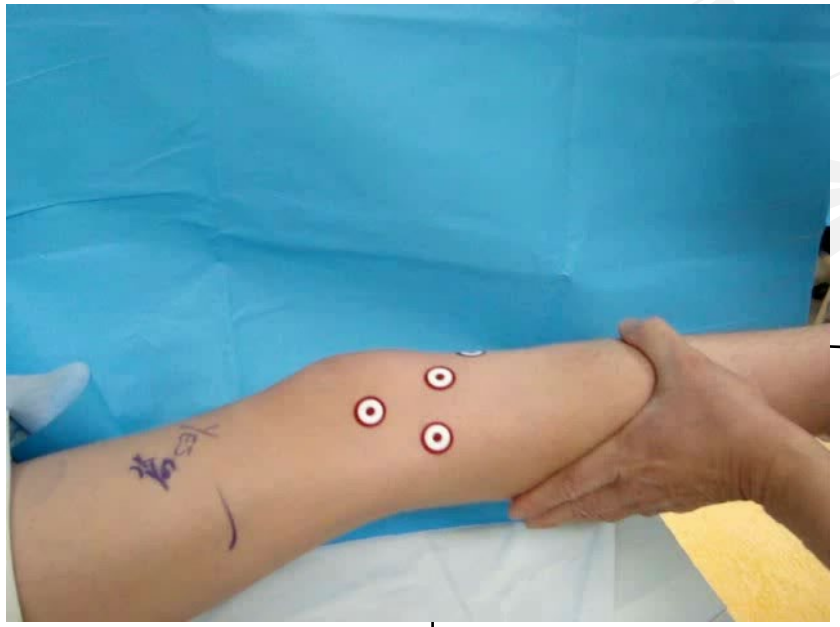
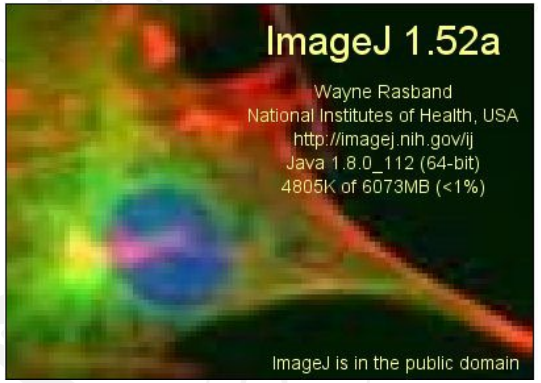


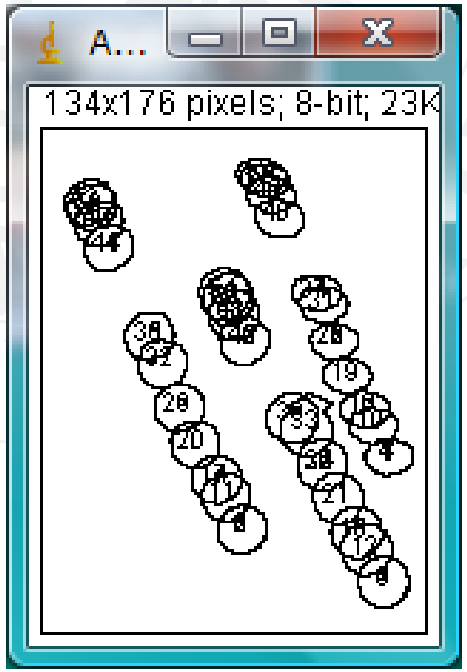
Image analysis evaluation of pivot-shift

Pictures from the movie data



Tracing the three markers





Results

File	Edit	Font	
	Area	X	Y
1	46	47.935	56.478
2	48	45.500	60
3	51	44.559	66.559
4	44	41.932	75.295

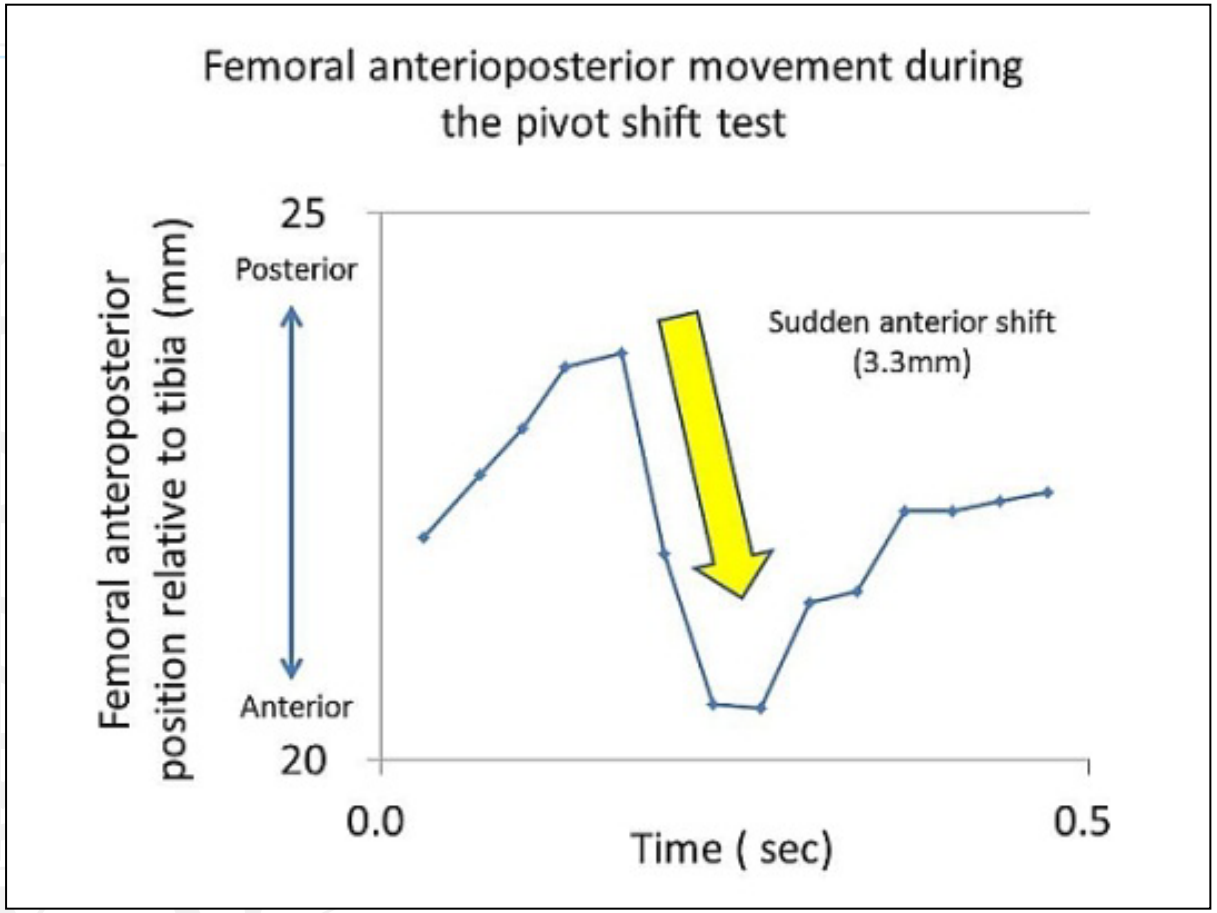
Image analysis evaluation of pivot-shift

Knee Surg Sports Traumatol Arthrosc
DOI 10.1007/s00167-011-1845-x

KNEE

An image analysis method to quantify the lateral pivot shift test

Yuichi Hoshino · Paulo Araujo · James J. Irrgang · Freddie H. Fu · Volker Musahl



Results – 20 cases

- Average translation - 3.6 ± 1.8mm
- Duration of the shift - 0.1 ± 0.1sec

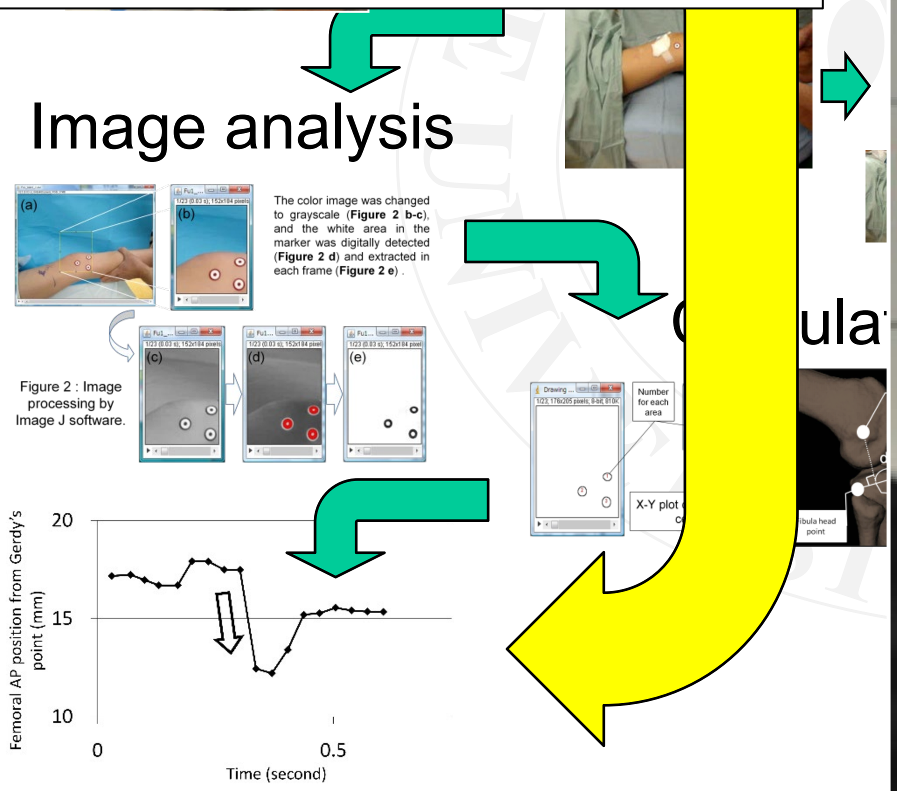
Image analysis evaluation using iPad

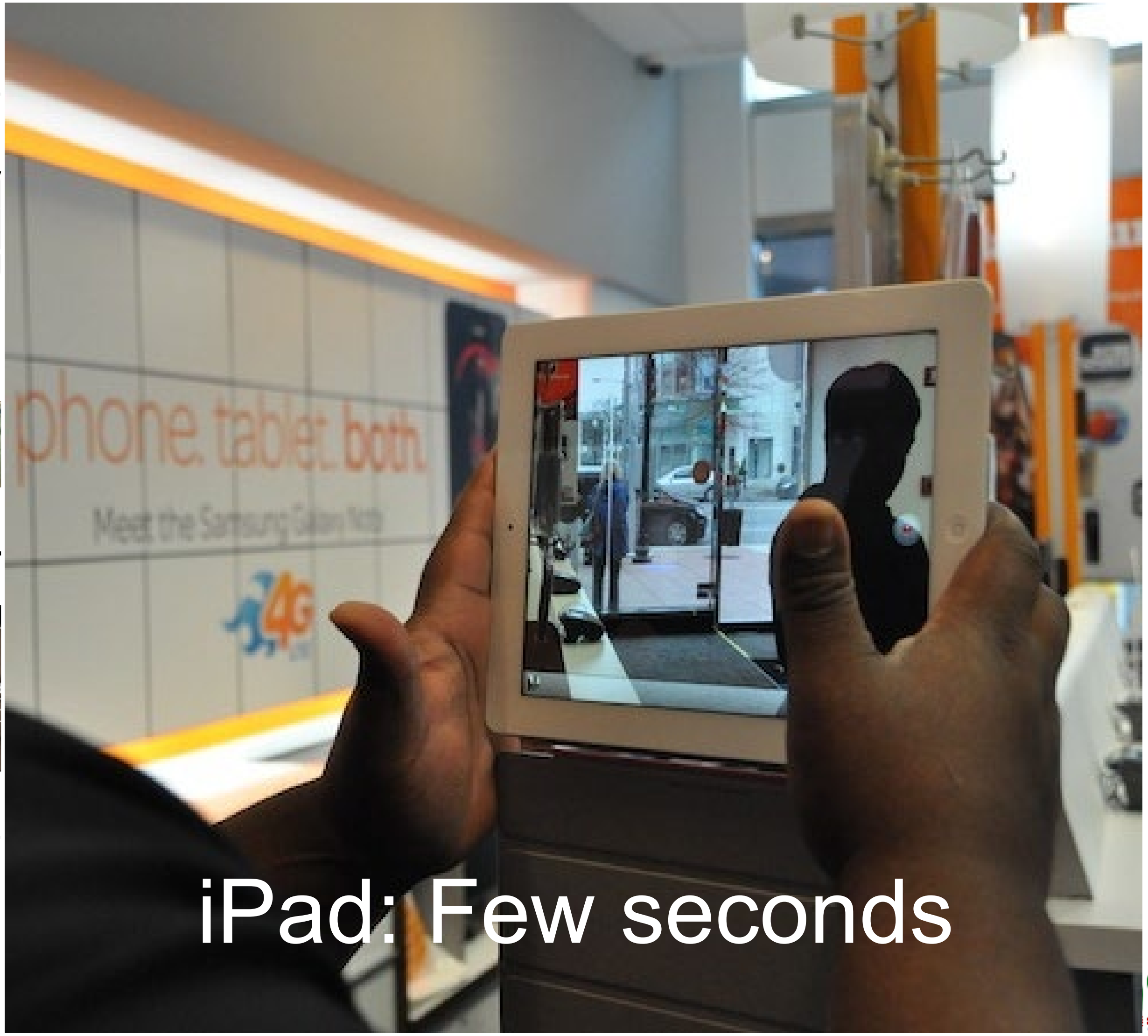
Knee Surg Sports Traumatol Arthrosc (2013) 21:975–980
DOI 10.1007/s00167-013-2396-0

KNEE

Quantitative evaluation of the pivot shift by image analysis using the iPad

Yuichi Hoshino · Paulo Araujo · Mattias Ahldén · Kristian Samuelsson · Bart Muller · Marcus Hofbauer · Megan R. Wolf · James J. Irrgang · Freddie H. Fu · Volker Musahl





Comparison of pivot-shift measurement systems

	EMS	Navigation	KiRA	iPad image analysis	Image analysis
Invasiveness	Non-invasive	Invasive	Non-invasive	Non-invasive	Non-invasive
Data analysis	complicated	complicated	Easy	complicated	easy
Accuracy	Excellent	Excellent	Good	Moderate	moderate
Values	**Ant. Translation & acceleration**	**Ant. Translation & acceleration**	**Acceleration**	**Lateral Ant. Translation**	**Lateral Ant. Translation**
Availability	Limited	Limited	Possible	Possible	Possible
Price	**High**	**High**	**Middle**	**iPad**	**Cheap**

NEJM approved “the quantitative pivot-shift testing”

The NEW ENGLAND JOURNAL of MEDICINE
VOL. 388 NO. 11

IF = 84.5

The NEW ENGLAND JOURNAL of MEDICINE

Anterior Cruciate Ligament Tear

Volker Musahl, M.D., and Jon Karlsson, M.D., Ph.D.

This Journal feature begins with a case vignette highlighting a common clinical problem. Evidence supporting various strategies is then presented, followed by a review of formal guidelines, when they exist. The article ends with the authors' clinical recommendations.

Quanti-tative pivot-shift testing, in which either translation of the lateral plateau or tibial acceleration is measured, has been validated in a clinical trial and can be used to assess concomitant soft-tissue injuries.[9,10]

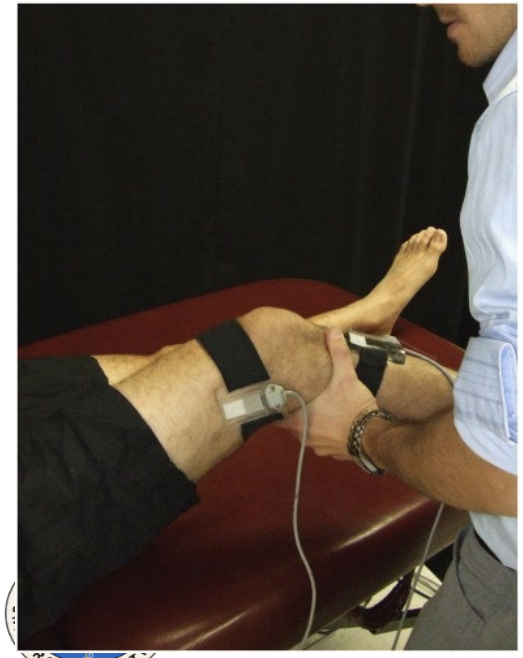
- **Musahl V, Karlsson J. 2019**

Pivot-shift : translation or acceleration??

Journal of Biomechanics
Volume 43, Issue 16, 1 December 2010, Pages 3080-3084

Feature selection using a principal component analysis of the kinematics of the pivot shift phenomenon

David R. Labbe [a, b], Jacques A de Guise [a, b], Neila Mezghani [a], Véronique Godbout [c], Guy Grimard [d], David Baillargeon [e], Patrick Lavigne [f], Julio Fernandes [g], Pierre Ranger [g], Nicola Hagemeister [a, b]



Relationship

Knee kinematics
vs
Clinical gradings

Factor loading of the pivot shift features.

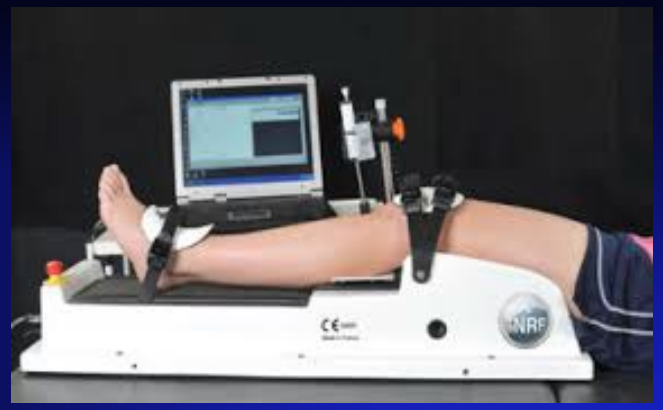
Pivot shift feature	Component			
	PC_1	PC_2	PC_3	PC_4
Total translation acceleration	0.840			
AP translation velocity	0.809			
Total translation velocity	0.799			
ML translation acceleration	0.758			
AP translation acceleration	0.693			
Abduction acceleration	0.669			
Tibial rotation velocity		0.930		
Tibial rotation acceleration		0.823		
Tibial rotation magnitude		0.670	0.526	
Abduction magnitude			0.828	
Total translation magnitude			0.726	
ML translation magnitude			0.642	
Abduction velocity			0.501	
ML translation velocity				0.757
AP translation magnitude				0.516

The features are listed in decreasing order of their factor loading values. To simplify the interpretation, the factor loadings lower than 0.5 are suppressed and are represented by blank spaces.

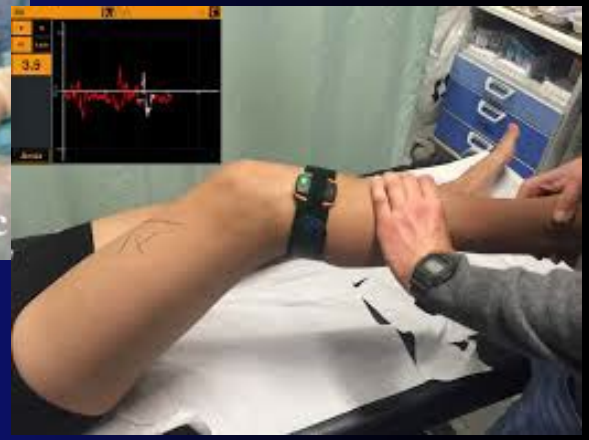
Other laxity measurements for ACL research

Other “**measurement devices**” for the ACL studies





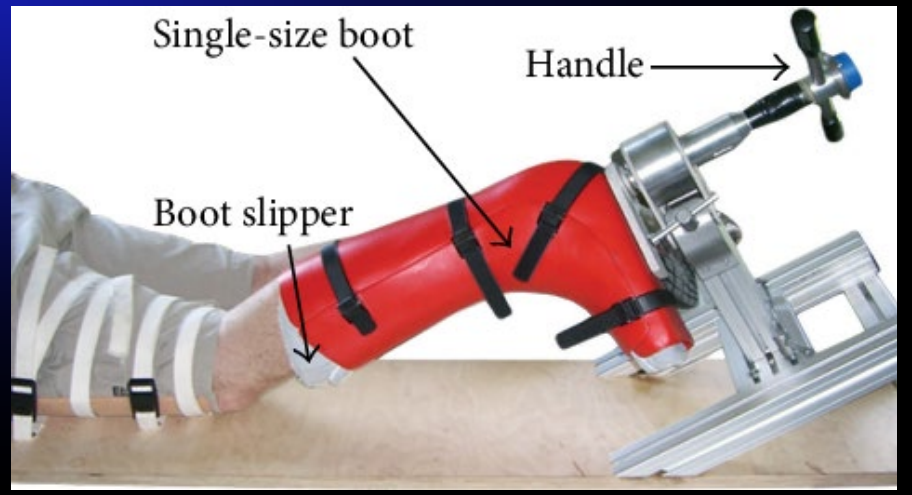












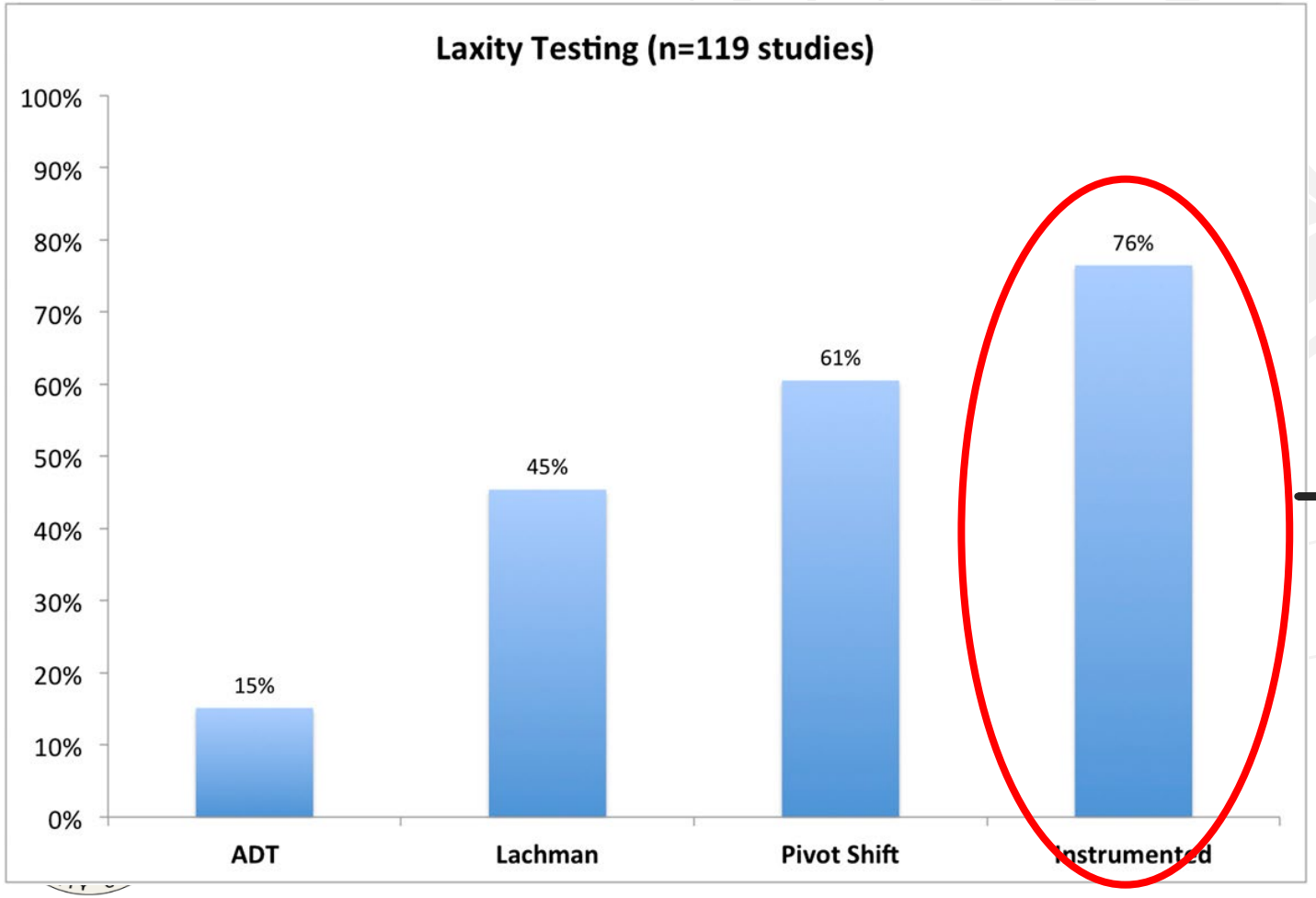


How often “**measurement devices**” are used?

Copyright © 2015 by The Journal of Bone and Joint Surgery, Incorporated

High Variability in Outcome Reporting Patterns in High-Impact ACL Literature

Makhni EC, et al. J Bone Joint Surg Am 2015



- **91 studies**
  - **KT - 77 (85%)**
  - **Telos - 10**
  - **Rolimeter - 5**
  - **e.t.c.**

"the classic" – KT measurement

- **Lachman test**



- **Anterior t**



KT-1000



easurement of anterior knee
s with acute anterior cruciate
tion

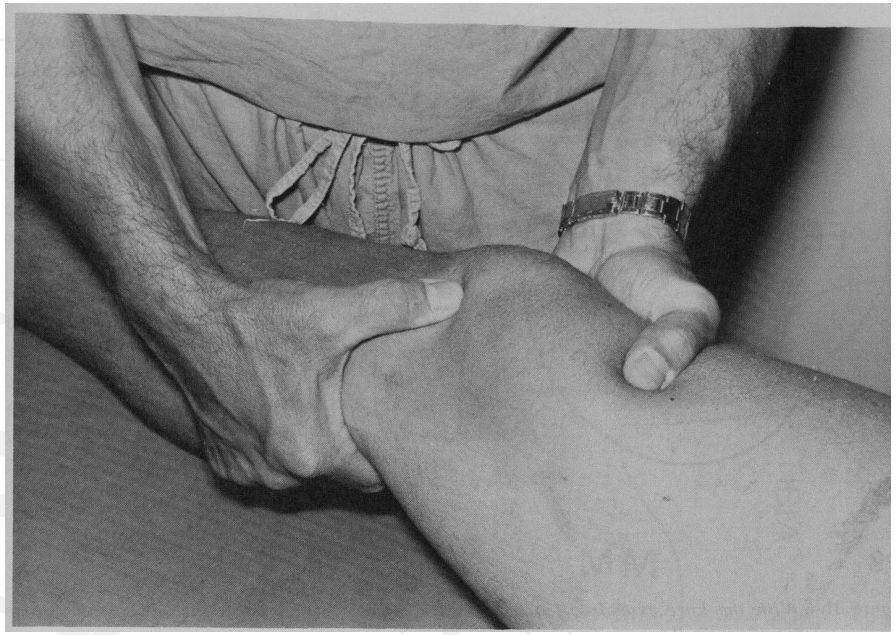
MARY LOU STONE, RPT, RAYMOND SACHS, MD, AND
LAWRENCE MALCOM,† PhD

AJSM 1985

Clinical value of KT-measurement

Lachman test

- Torg et al, AJSM 1972



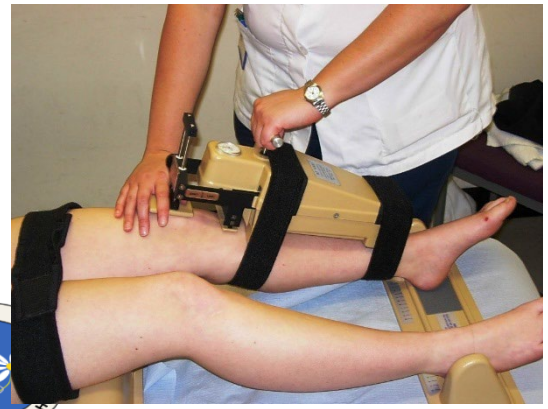
✓ Sensitivity 85% /

Specificity 94% for ACL-D

- Benjaminse et al, J Orthop Sports Phys Ther 2006

→ Instrumented measurement of anterior laxity (KT)

- Daniel et al, JBJS Am 1985



No relation to subjective knee functions

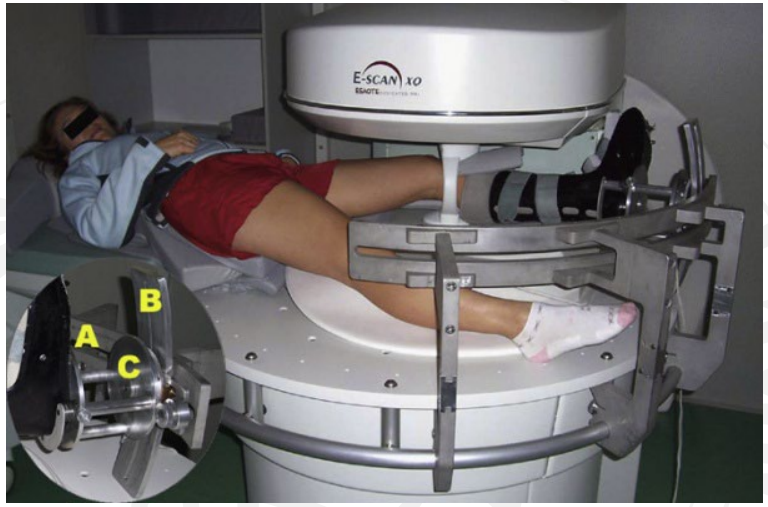
- Snyder-Mackler et al, AJSM 1997, Kocher et al, AJSM 2004

How about “rotational” laxity?

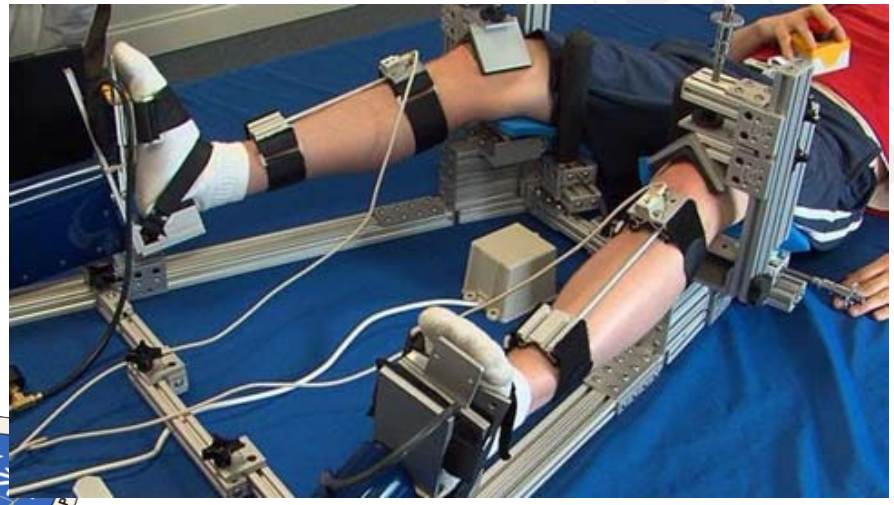
Axial rotation against rotational torque



Espregueira-Mendes et al KSSTA 2012



Hemmerich et al J Biomech 2009



Branch et al KSSTA 2010

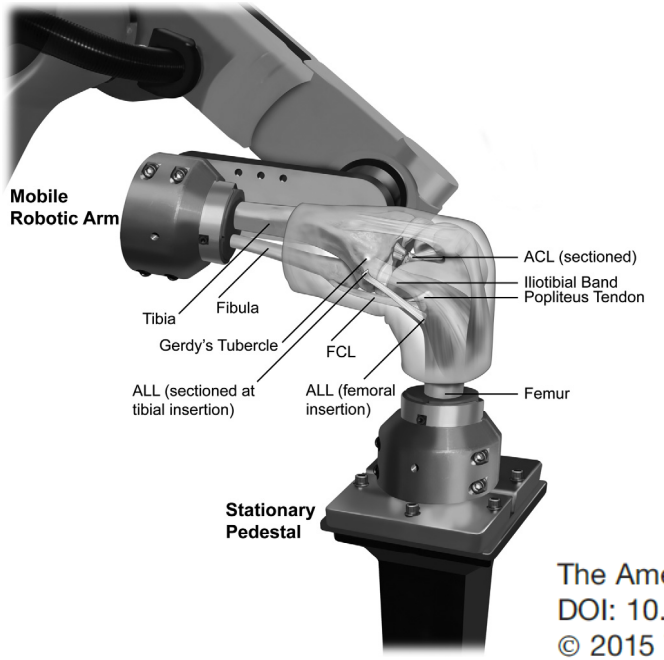
Not established yet.

ACL injury increases Tibial Internal rotation

An In Vitro Robotic Assessment of the Anterolateral Ligament, Part 1

Secondary Role of the Anterolateral Ligament in the Setting of an Anterior Cruciate Ligament Injury

Matthew T. Rasmussen,* BS, Marco Nitri,* MD, Brady T. Williams,* BS, Samuel G. Moulton,* BA, Raphael Serra Cruz,* MD, Grant J. Dornan,* MSc, Mary T. Goldsmith,* MSc, and Robert F. LaPrade,*†‡ MD, PhD
Investigation performed at the Department of BioMedical Engineering, Steadman Philippon Research Institute, Vail, Colorado, USA



The American Journal of Sports Medicine, Vol. 44, No. 3
DOI: 10.1177/0363546515618387
© 2015 The Author(s)

- **"Isolated" ACL deficient increased in internal rotation by 2º or less compared to the intact state**

The impact of the ACL on axial “rotation”

In vivo study

Difficult to detect ACL injury by applying simple axial rotational stress

- **Individual variability**

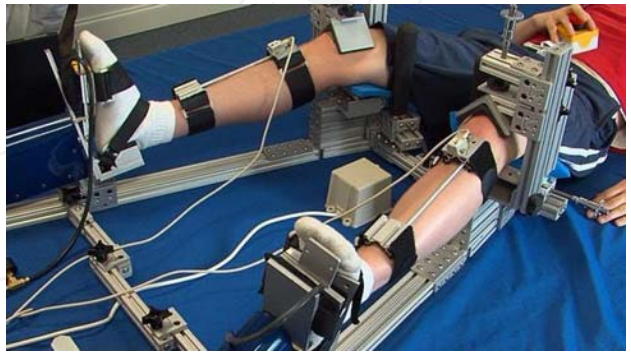
Mouton et al KSSTA 2012



Hemmerich et al J Biomech 2010



Lorbach et al KSSTA 2009

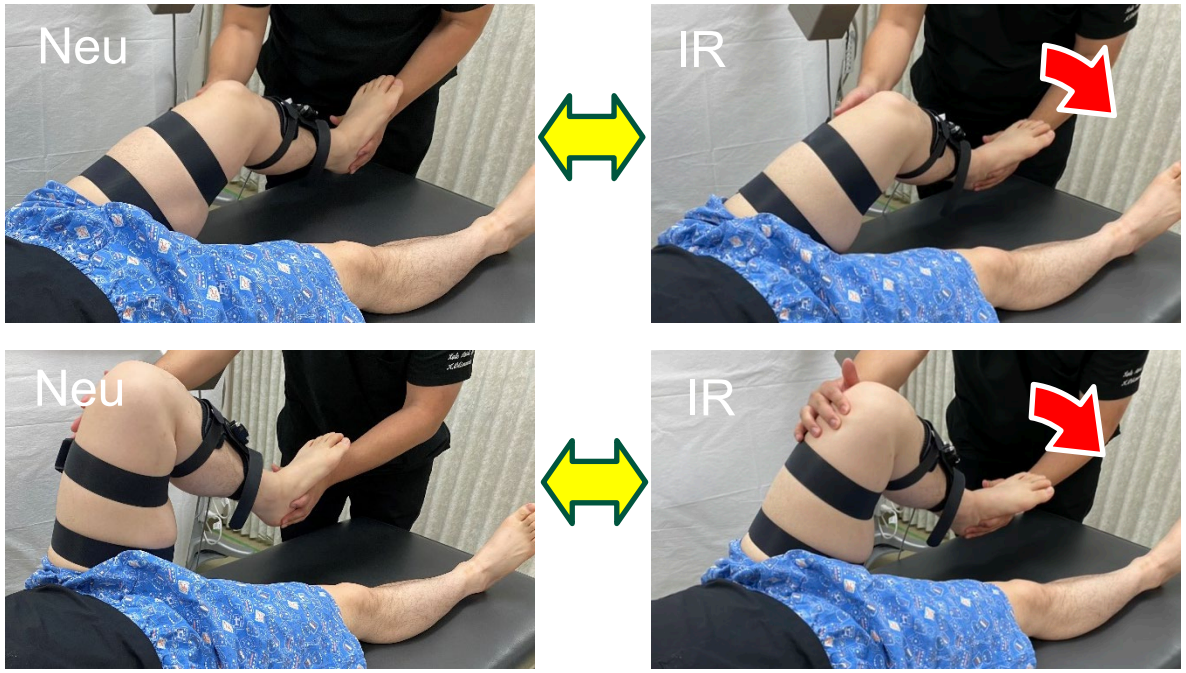


Branch et al KSSTA 2010

Axial rotational laxity in ACL injured knees

How much of rotational laxity does "isolated" ACL injured knee have?

Electromagnetic measurement of axial rotation (deg) at 30/60/90°



No rotational stress　　Internal rotation

57 ACL "isolated" injured pts
(26 males/31 females)
without any meniscus tear

- Increase of internal rotation vs intact knee

		+10° more	
at 30°	**3.4°**±8.9	**13**	cases
at 60°	**2.3°**±8.6	**9**	cases
at 90°	**0.8°**±7.9	**8**	cases

Okimura K, et al TOSSM 2024

FIFA® MEDICAL CENTRE OF EXCELLENCE

Latest topic about ACL

KOBE UNIVERSITY ORTHOPAEDICS

KOBE UNIVERSITY

Anterolateral Ligament movement: 2013~

Journal of Anatomy

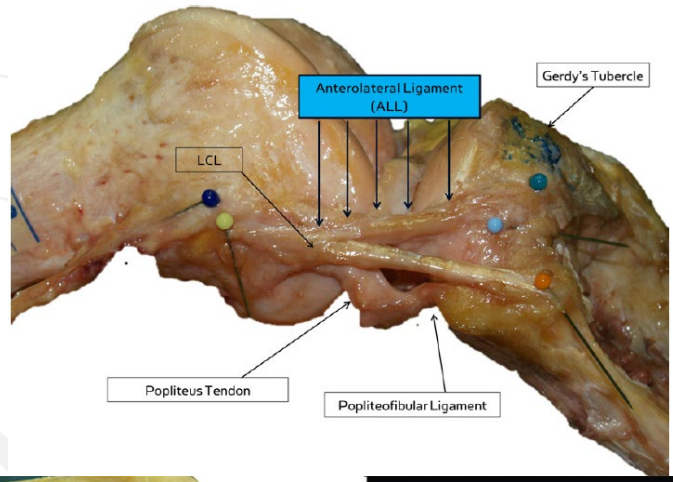
doi: 10.1111/joa.12087

J. Anat. (2013) 223, pp321–328

Anatomy of the anterolateral ligament of the knee

Steven Claes,[1] Evie Vereecke,[2] Michael Maes,[1] Jan Victor,[3] Peter Verdonk[4] and Johan Bellemans[1]

[1]*Department of Orthopedic Surgery & Traumatology, University Hospitals Leuven, Leuven, Belgium*
[2]*Department of Development and Regeneration, Faculty of Medicine@Kulak, Catholic University Leuven, Kortrijk, Belgium*
[3]*Department of Orthopedic Surgery & Traumatology, University Hospital Gent, Ghent, Belgium*
[4]*Antwerp Orthopedic Center, Monica Hospitals, Antwerp, Belgium*

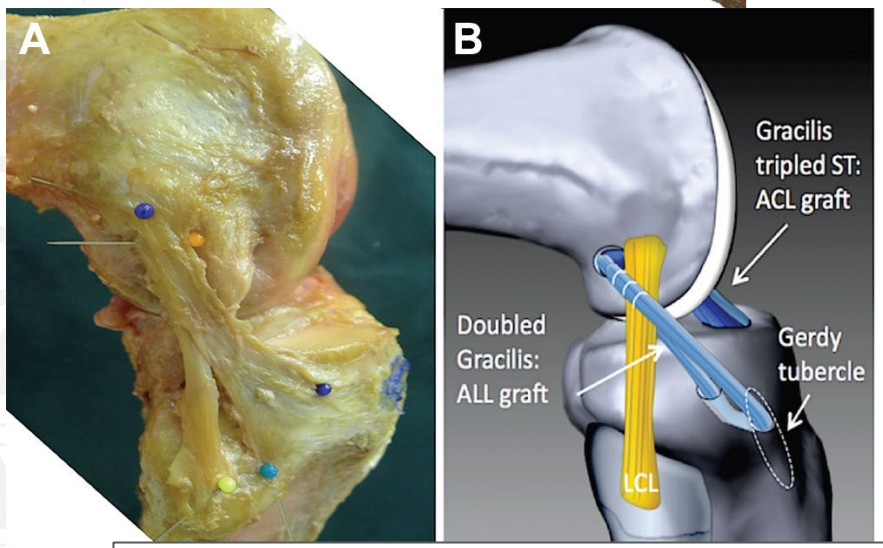


PODCAST 5-in-5

Outcome of a Combined Anterior Cruciate Ligament and Anterolateral Ligament Reconstruction Technique With a Minimum 2-Year Follow-up

Bertrand Sonnery-Cottet,*† MD, Mathieu Thaunat,† MD, Benjamin Freychet,† MD, Barbara H.B. Pupim,† MD, Colin G. Murphy,† MD, and Steven Claes,‡ MD, PhD
Investigation performed at the Centre Orthopédique Santy, Hôpital Privé Jean Mermoz, Lyon, France

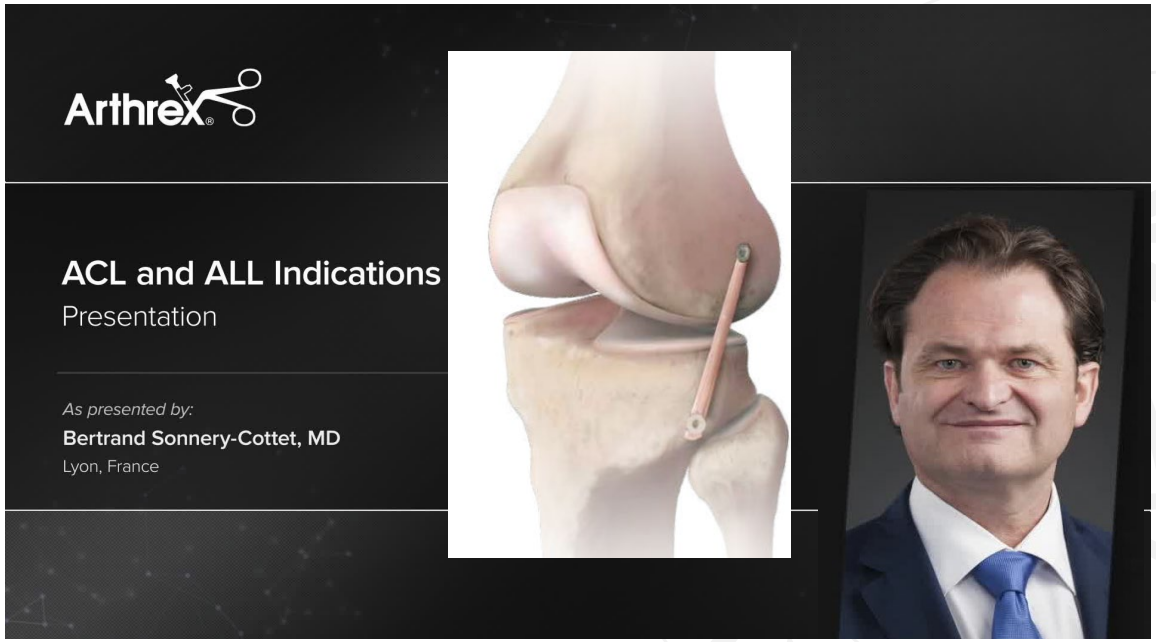
Am J Sports Med. 2015 Jul;43(7):1598-605.



In a consecutive series of 396 ACL reconstructions performed between January 2011 and January 2012 by the first author (B.S-C.), 92 combined ACL reconstructions with minimally invasive ALL reconstructions were carried out (Figure 1). All patients had experienced a knee trauma

LEAP (Lateral Extraarticular Procedure)

ALL: Anterolateral ligament reconstruction

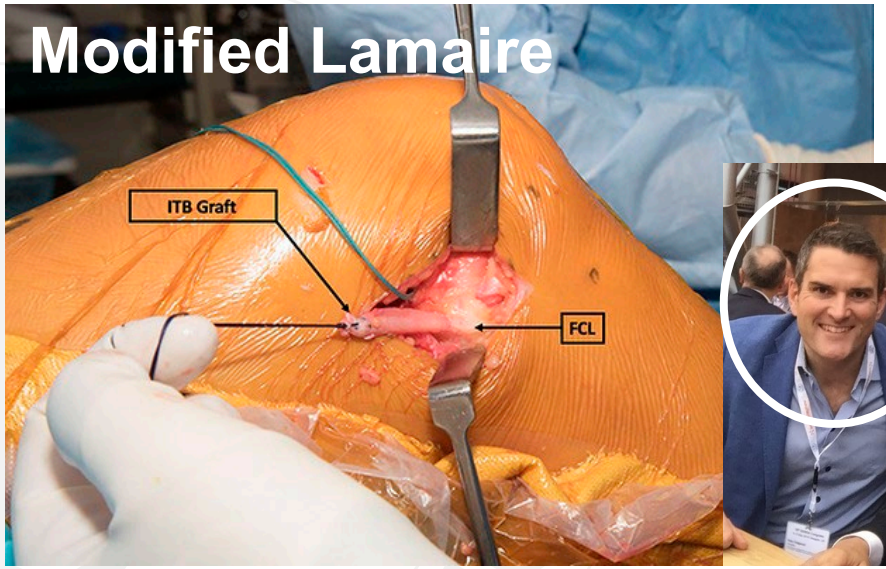


- ALL for all ACLR
- Better than revision

AJSM 2022

- Cohort study; Level of evidence, **3**
- **ACLR(BTB) vs ACLR + ALLR**
- **20.5% vs 8.9% (p< .01)**

LET: Lateral extraarticular tenodesis





3 criteria for high-risk (>2 high risk)

(1) grade 2 pivot shift or greater,
(2) a desire to return to high-risk/pivoting sports
(3) generalized ligamentous laxity (GLL)

AJSM 2020

- Randomized controlled trial; Level of evidence, **1**
- **ACLR vs ACLR + LET**
- **11% vs 4% (p< .01)**

LET indication in the report from Getgood et al.

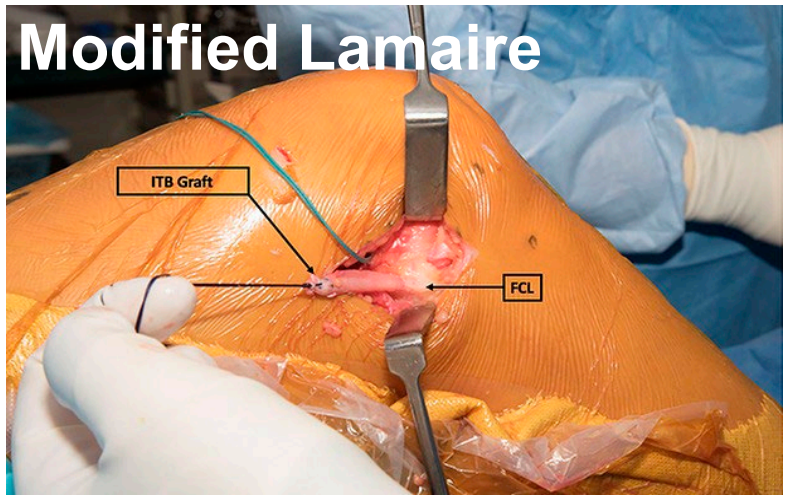
Winner of the O'Donoghue Sports Injury Award

Lateral Extra-articular Tenodesis Reduces Failure of Hamstring Tendon Autograft Anterior Cruciate Ligament Reconstruction

2-Year Outcomes From the STABILITY Study Randomized Clinical Trial

Alan M.J. Getgood,* MD, FRCS(Tr&Orth), Dianne M. Bryant, MSc, PhD, Robert Litchfield, MD, FRCSC, Mark Heard, MD, FRCSC, Robert G. McCormack, MD, FRCSC, Alex Rezansoff, MD, FRCSC, Devin Peterson, MD, FRCSC, Davide Bardana, MD, FRCSC, Peter B. MacDonald, MD, FRCSC, Peter C.M. Verdonk, MD, PhD, Tim Spalding, FRCS, and the STABILITY Study Group
Investigation performed at The Fowler Kennedy Sport Medicine Clinic, Western University, London, Ontario, Canada

Am J Sports Med. 2020 Feb;48(2):285-297.



2+ of 3 criteria – "high-risk"

I. **grade 2 pivot shift** or greater
II. a desire to return to high-risk / pivoting sports
III. generalized ligamentous laxity (GLL)

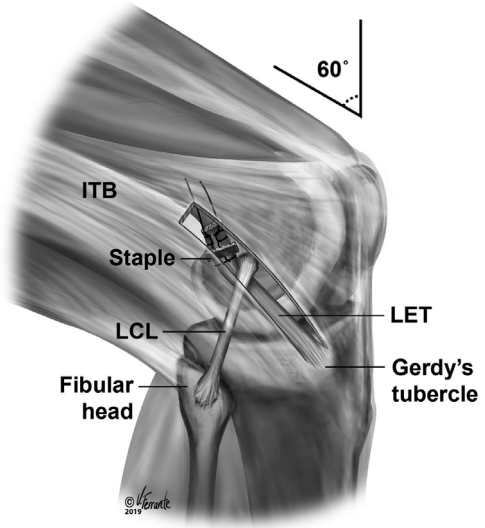
LET reduces Tibial Internal Rotation

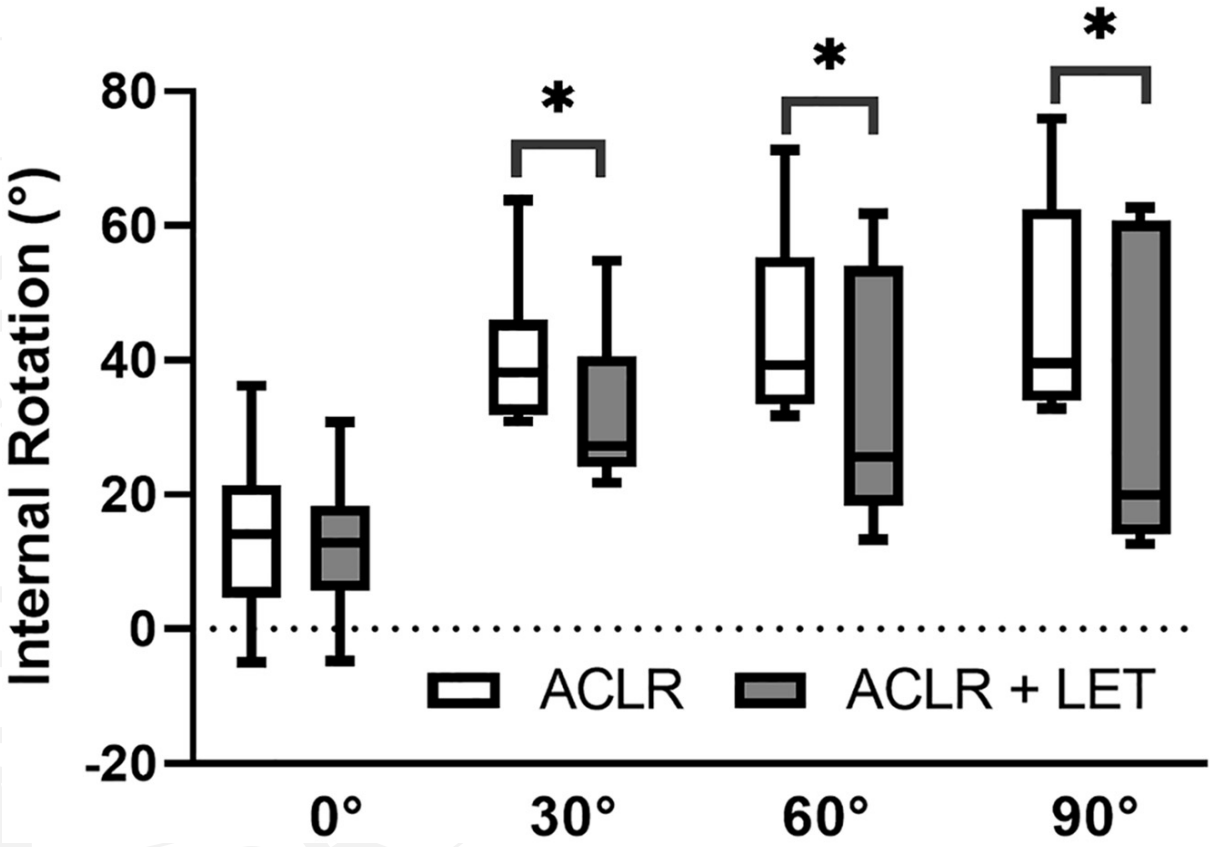
The American Journal of Sports Medicine
2024;52(1):87–95

Role of Lateral Extra-articular Tenodesis in Restraining Internal Tibial Rotation

In Vitro Biomechanical Assessment of Lateral Tissue Engagement

Zahab S. Ahsan,* MD, Erin E. Berube,† MS, Brian J. Frondorf,† MD, Ho Bin Kim,† BS, Niv Marom,* MD, Zaid A. Zayyad,† MD, Thomas J. Fraychineaud,† MD, Ronak M. Patel,* MD, Thomas L. Wickiewicz,* MD, Carl W. Imhauser,†‡ PhD, Andrew D. Pearle,* MD, and Danyal H. Nawabi,* MD
Investigation performed at Hospital for Special Surgery, New York, New York, USA





Conclusion : **LET increased restraint to IR of the tibia** compared with the anterolateral tissue, particularly at 30, 60, and 90 of flexion.

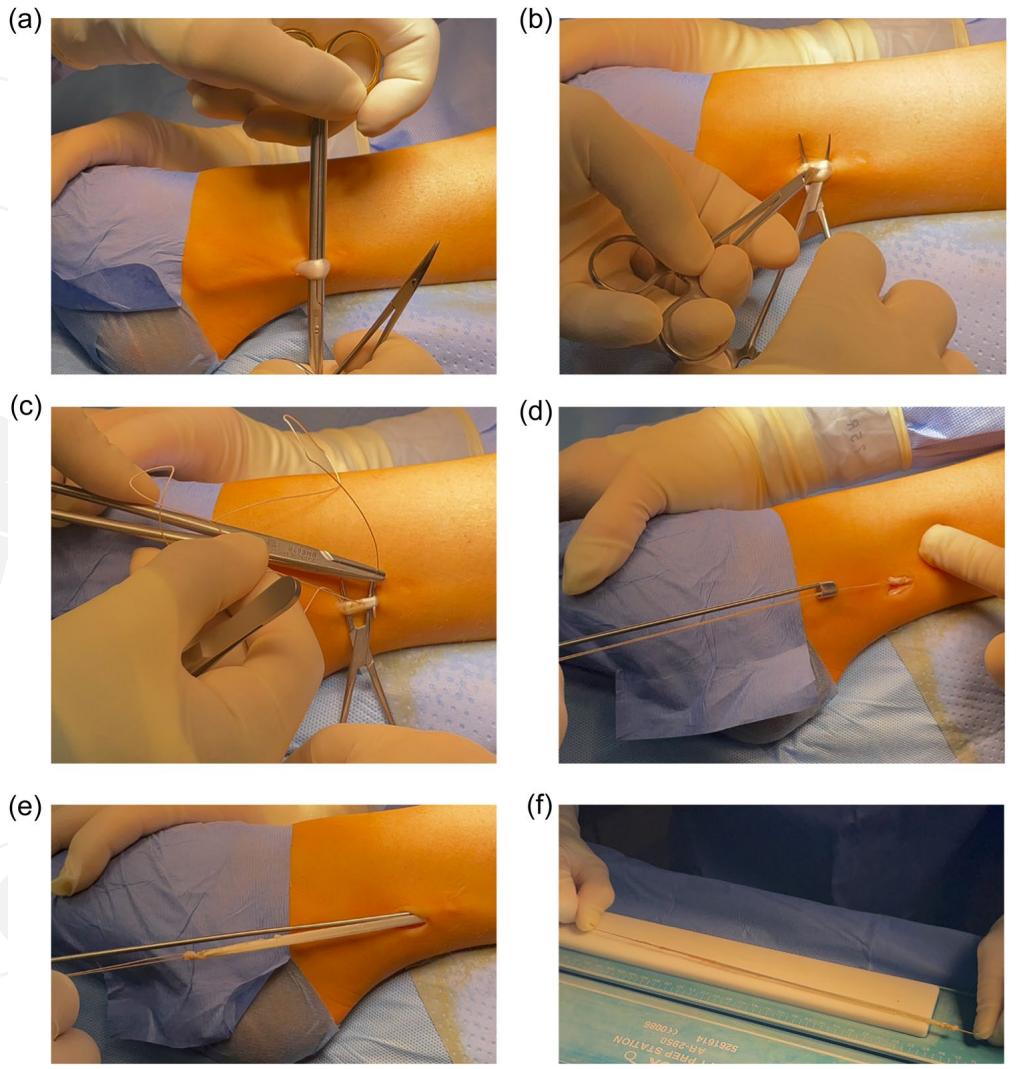
Peroneus longs tendon autograft for ACL-R

Surgical Techniques

Peroneus Longus Tendon Autograft: A Promising Graft for ACL Reconstruction

Nicolaas C. Budhiparama,*†‡§‖ MD, PhD, Sholahuddin Rhatomy,§¶ MD, Krisna Yuarno Phatama,# MD, William Chandra,** MD, Asep Santoso,†††‡‡ MD, and Imelda Lumban-Gaol,† MD
Investigation Performed at Dr Soeradji Tirtonegoro General Hospital, Klaten, Indonesia

Video J Sports Med. 2021 Jul 13;1(4):26350254211009888. doi: 10.1177/26350254211009888. PMID: 40309384; PMCID: PMC11883406.



The most common complication was hypoesthesia around the lateral side of the foot, although the ankle functions were not affected significantly.

Cakar A, Kose O, Selcuk H, Egerci OF, Tasatan E, Dogruoz F. Complications of peroneus longus tendon harvesting: a retrospective review of 82 cases. Arch Orthop Trauma Surg. 2023 Nov;143(11):6675-6684.

PLT autograft for other ligaments

VJSM Fellows Video Challenge

Medial Patellofemoral Ligament Reconstruction Using the Anterior Half of the Peroneus Longus Tendon Graft

Bruno Butturi Varone,*† MD, André Giardino Moreira da Silva,† MD, Fernando Loureiro Miranda,† MD, Ricardo Gomes Gobbi,† MD, PhD, and Camilo Partezani Helito,† MD, PhD
Investigation performed at Hospital das Clínicas da Faculdade de Medicina da USP, University of São Paulo, São Paulo, Brazil

Video J Sports Med. 2025 Aug 28;5(4):26350254251347310. doi: 10.1177/26350254251347310. PMID: 40895500; PMCID: PMC12394841.

KNEE

Knee Surgery, Sports Traumatology, Arthroscopy WILEY

MCL augmentation using a peroneus longus split tendon autograft satisfactorily restores knee stability with no impairment in foot function and with a low failure rate for concurrent ACL reconstruction

Nico Hinz[1,2] | Maximilian Michael Müller[1] | Lena Eggeling[1,2] | Tobias Drenck[1] | Stefan Breer[1] | Birgitt Kowald[3] | Karl-Heinz Frosch[1,2] | Ralph Akoto[1,4]

Knee Surg Sports Traumatol Arthrosc. 2025 Jun;33(6):2122-2135. doi: 10.1002/ksa.12522. Epub 2024 Oct 30. PMID: 39474848; PMCID: PMC12104778.

Take home message for future sports biomechanists

- Pivot-shift is a key because of high clinical value in ACL research.
- Quantitative evaluation should be established.

"Objective" evaluation of "clinically relevant" parameter should be conducted.

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Thank you for your attention.