Cruciate ligaments: What do we know by now/ A (short?) review

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Advisor; Virtamed AG, Schlieren/ZH (Simulators for arthroscopy), **Medical Insights Inc. Basel** (Open medical platform for HCPs)

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Do we have a problem?

Knee Surgery, Sports Traumatology, Arthroscopy
https://doi.org/10.1007/s00167-018-4886-6

EDITORIAL

Let us rethink research for ACL injuries: a call for a more complex scientific approach

Alli Gokeler[1] · Evert Verhagen[2,3,4,5] · Michael T. Hirschmann[6,7]

Received: 8 January 2018 / Accepted: 28 February 2018


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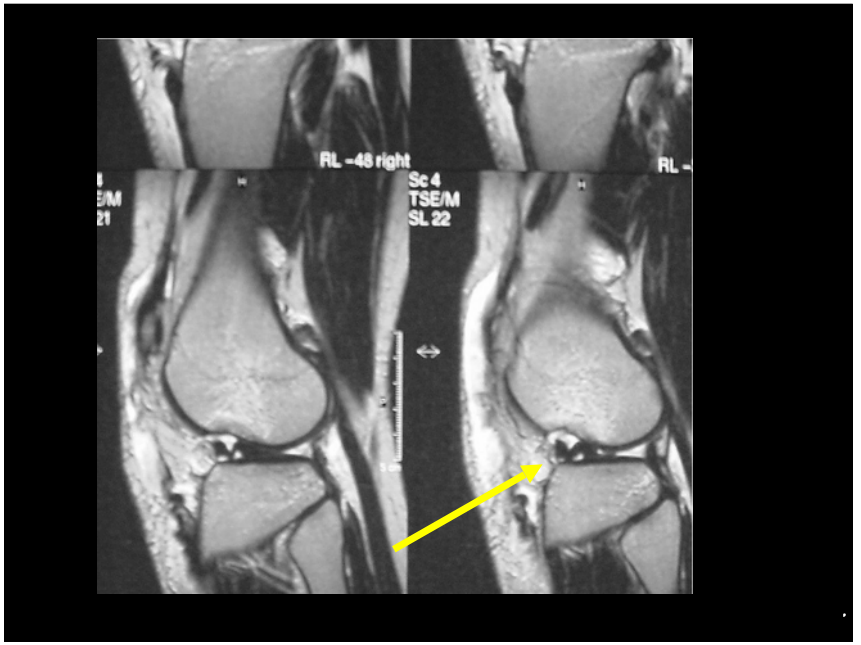
RL -17 right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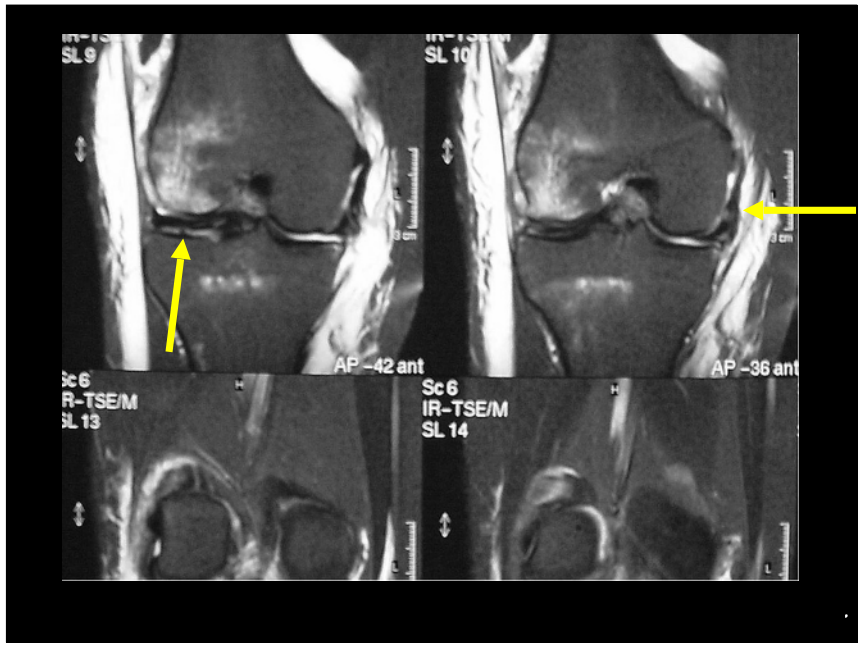
AP -42 ant
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Sc 6
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SL 14


SF sport
SF zwei
SANDRA GINI

NOV 29, 2000 - 11:40

One of Switzerland's young skiing hopefuls, Nadia Styger, is heading home after suffering a knee injury during training for the first women's World Cup downhill race of the season.

Nadia Styger's season has got off to a bad start.

(Keystone / Laurent Gilieron)

The 21 year-old hurt her left knee in a fall on the course at Lake Louise in Canada.

Doctors said she had damaged her meniscus, but were unable to be more precise. Further investigations will be carried out in Switzerland to determine whether the ligaments are damaged.

It is Styger's third serious knee injury in her short skiing career. She missed the entire 1997/98 season after tearing the ligaments in her right knee, and last December damaged the ligaments in her left knee during a race in Veysonnaz.

At Lake Louise, another young skier, Austria's Kerstin Reisenhofer, had a more serious fall spelling the end of the season for her.

After the first training run, Italy's Isolde Kostner has the fastest time, followed by Canada's Melanie Turgeon, Michaela Dorfmeiser of Austria, and the Swiss skier, Sylviane Berthod.

swissinfo with agencies

January 19, 2006 / By

St. Moritz: Kostelic unfazed by return to site of 1999 knee injury

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St. Moritz: Kostelic unfazed by return to site of 1999 knee injury{mosimage}ST. MORITZ, Switzerland – On Thursday, overall World Cup leader Janica Kostelic faced the Corviglia downhill course for the first time since tearing ligaments in her right leg in a crash here six years ago.

Kostelic, who has avoided this annual downhill race and other tricky speed races since the accident, said she had put aside all thoughts of the crash.

"I don't think about it," said Kostelic, who finished 13th in the only training run for Saturday's race. "It was a strange jump at the time and they changed it after I crashed, so it was obvious something was wrong with it."

The Croat tore four knee ligaments and badly damaged two more during downhill practice in 1999, soaring off an artificial jump and landing precariously on her right leg before falling on her back and ending up in the safety netting.

She was just one of the numerous skiers – along with Switzerland's Sylviane Berthod, Austria's Silvia Berger and Kristine Kristiansen of Norway – to tear knee ligaments during that weekend which ended all their seasons.

On Thursday, Kostelic clocked in at 1 minute, 46.18 seconds in training, and said she actually liked the Rominger jump at the bottom of the course.
"It's nice. It's not dangerous, you go far and not too high," Kostelic said. "I like normal jumps. I like far jumps but not high jumps."

Kostelic did run the downhill leg for the combined event – which she won – at the 2003 World Championships at St. Moritz, but on a different track.

Nicole Hosp of Austria had the fastest time of 1:45.12 in her first World Cup downhill training session. She said she was familiar with the course after winning a lower-tier Europa Cup downhill here last week. Hosp was followed by teammate Michaela Dorfmeister, who clocked 1:46.76. Fraenzi Aufdenblatten was third in 1:45.78, 0.19

One race
One weekend

Four ACL ruptures in elite skiers

1999

Ilka Stuhec ist im alpinen Skisport zur Dauersiegerin geworden – auch wenn sie sich im letzten Super-G der Saison geschlagen geben muss. Diesmal weint eine andere vor Freude.

Es wurde viel geweint in diesem Winter im Skiteam von Ilka Stuhec. Von Dezember bis März. Vom Weltcup-Auftakt in Lake Louise über die Ski-WM in St. Moritz bis zum Alpinfinale in Aspen. Immerzu Tränen, und fast immer Tränen der Freude. Die Slowenin Ilka Stuhec hat die Aschenputtel-Geschichte der Saison geschrieben. Mit sich selbst in der Hauptrolle. Die scheinbar ewige Mitfahrerin aus Slovenj Gradec, die lange im Schatten ihrer strahlenden Landsfrau Tina Maze stand; die Pechmarie, die fünf Knieoperationen überstehen musste – sie wurde zum Glückskind. Und auch wenn ihre Erfolgsserie nicht ganz bis zum Schluss reichte, blickt die 26-Jährige doch auf eine erstaunliche Saison zurück.

Viletta im Pech

Kvitfjell. Sandro Viletta ist erneut im Verletzungspech. Der 32-jährige Bündner zog sich bei einem Sturz in der Europacup-Abfahrt von Kvitfjell einen Kreuzbandriss im linken Knie sowie eine Gehirnerschütterung zu. Erst Ende 2016 verletzte sich der Engadiner schwer am Knie und arbeitet seither an seiner Rückkehr in den Weltcup. Seinen letzten Einsatz dort hatte er im Dezember 2016 in Val Gardena. Wie Swiss-Ski in einem Communiqué schrieb, wird Viletta in nächster Zeit über die weiteren Schritte in seiner Karriere entscheiden. SDA

March 2018

Ski alpin

Mani riss sich Kreuzband

Kvitfjell. Nils Mani zog sich bei seinem Sturz in der Weltcup-Abfahrt am Samstag in Kvitfjell eine schwere Knieverletzung zu. Der 25-jährige Berner riss sich das vordere Kreuzband im rechten Knie und verletzte sich zudem am inneren Meniskus. Der Junioren-Weltmeister in der Abfahrt von 2013 hat den Durchbruch im Weltcup bislang nicht geschafft. Erst zweimal fuhr Mani in die Top Ten, sein bestes Ergebnis in diesem Winter war ein 21. Rang in der Kombination von Wengen. SDA

March 2018

Weltcup Frauen

Olympia-Aus für Ilka Stuhec?

Abfahrtsweltmeisterin Ilka Stuhec hat sich bei einem Trainingssturz schwer verletzt. Gemäss slowenischen Medienberichten zog sie sich einen Kreuzbandriss im linken Knie zu.

Sonntag, 22.10.2017, 18:43 Uhr

Dieser Artikel wurde 7-mal geteilt.

Basel

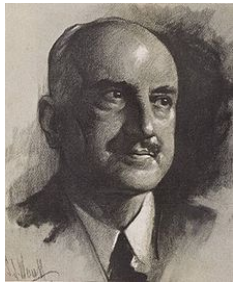
Ilka Stuhec erfolgreich in Basel operiert

27.10.2017 16:52 Aliena Müller

Ilka Stuhec ist am Donnerstag, 26. Oktober 2017, im Basler Universitätsspital erfolgreich am linken Knie operiert worden.

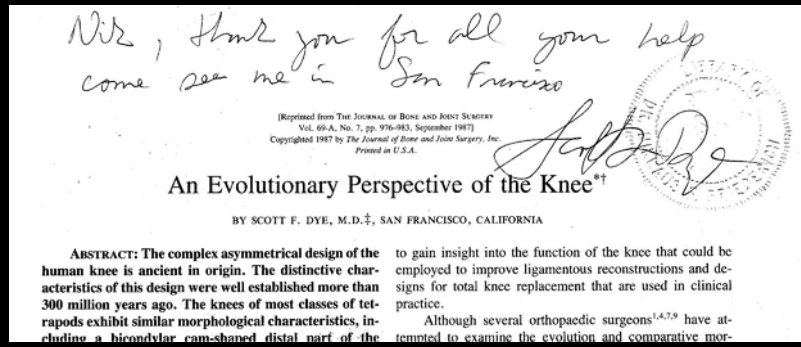
Alpine skiing downhill 2017 world champion, Slovenian athlete Ilka Stuhec gives a press conference after undergoing knee surgery at Basel's university hospital on October 27, 2017. Downhill world champion Ilka Stuhec looks set to miss February's Winter Olympics after tearing knee ligaments in practice on Sunday, her agent revealed. The 26-year-old was on hot form last season, winning the crystal globe in the downhill World Cup and silver in the Super-G at the world championships as well as her world title in the downhill.

Functional Anatomy



Those who cannot remember the past are condemned to repeat it

George Santayana ‚The Life of Reason'
1905/06



Nick, thank you for all your help
come see me in San Francisco

[Reprinted from The Journal of Bone and Joint Surgery
Vol. 69-A, No. 7, pp. 976-983, September 1987]
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An Evolutionary Perspective of the Knee*†

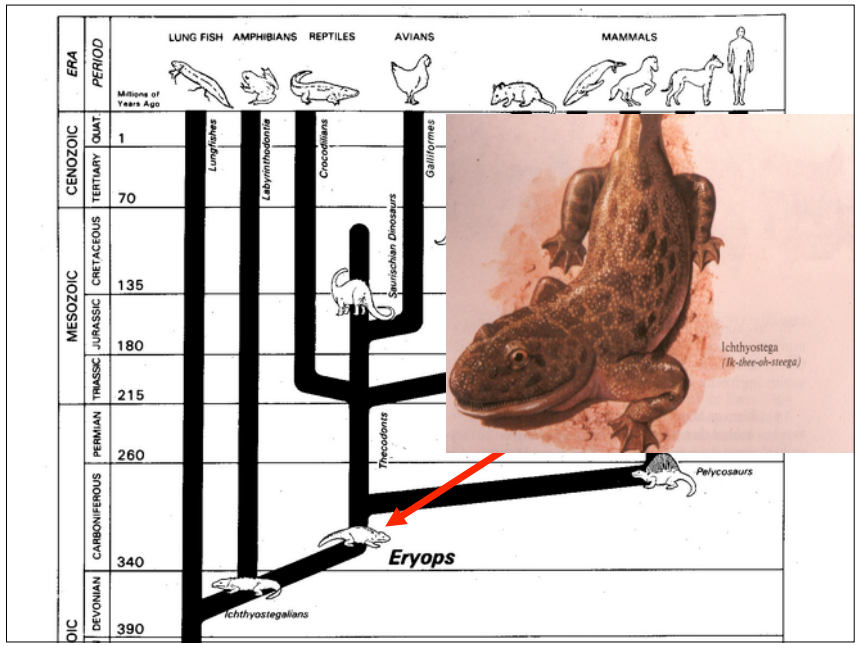
BY SCOTT F. DYE, M.D.‡, SAN FRANCISCO, CALIFORNIA

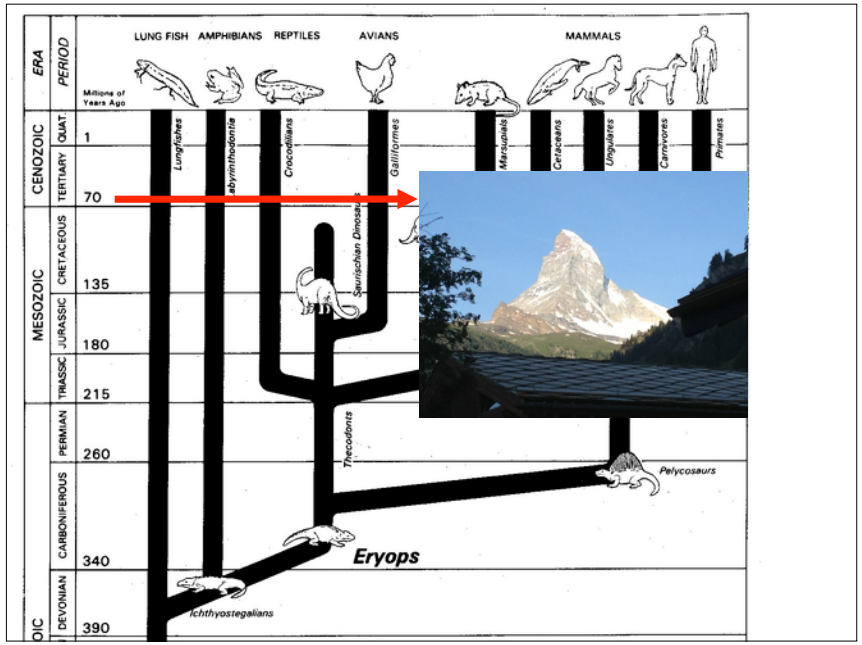
ABSTRACT: The complex asymmetrical design of the human knee is ancient in origin. The distinctive characteristics of this design were well established more than 300 million years ago. The knees of most classes of tetrapods exhibit similar morphological characteristics, including a bicondylar, cam-shaped distal part of the

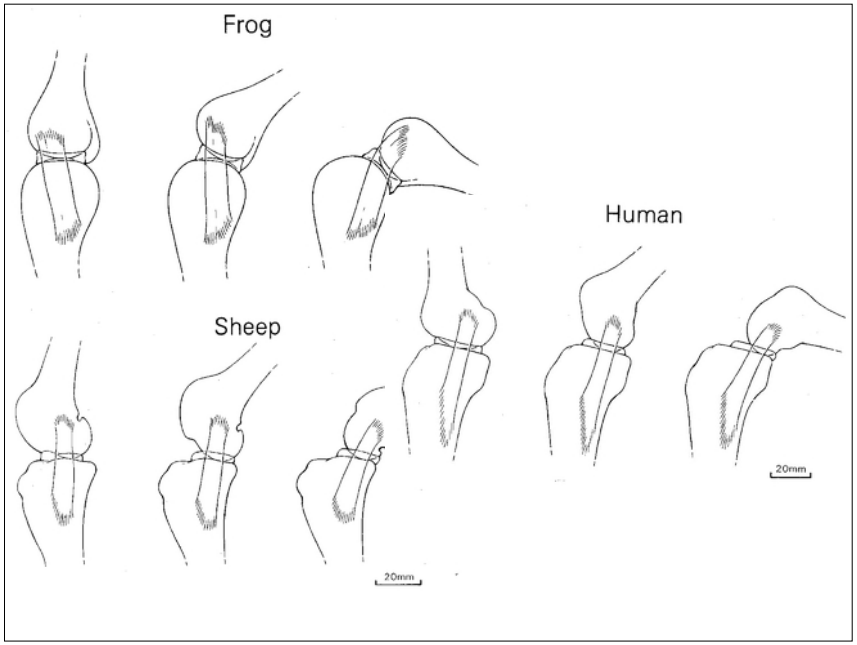
to gain insight into the function of the knee that could be employed to improve ligamentous reconstructions and designs for total knee replacement that are used in clinical practice.

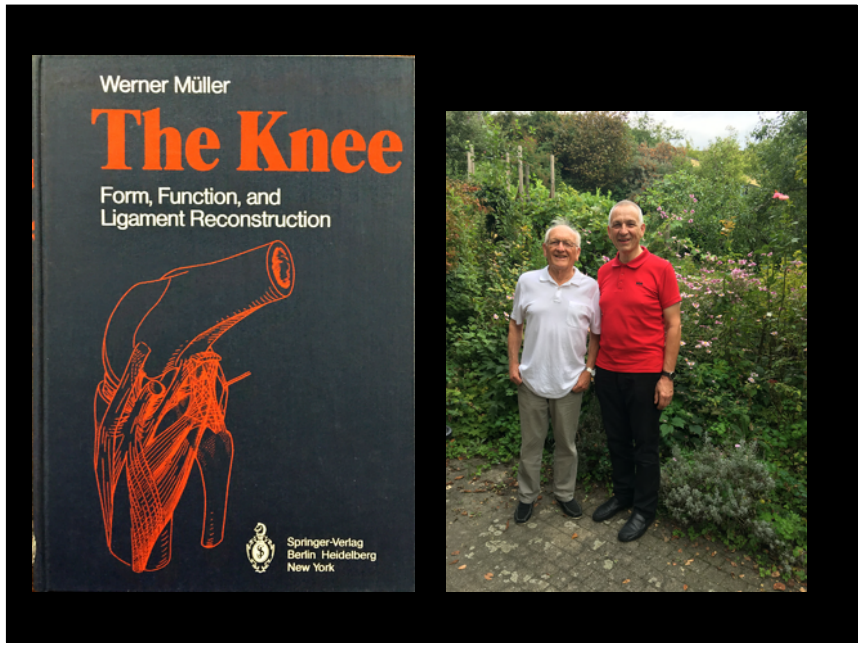
Although several orthopaedic surgeons[1,4,7,9] have attempted to examine the evolution and comparative mor-

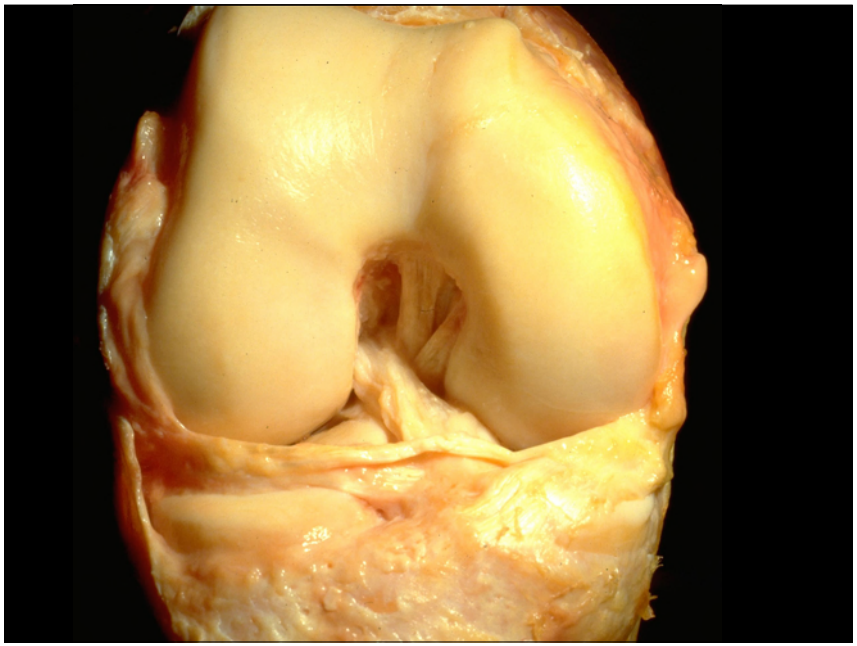
Dye SF: J Bone Joint Surg 69A, 976-983, 1987

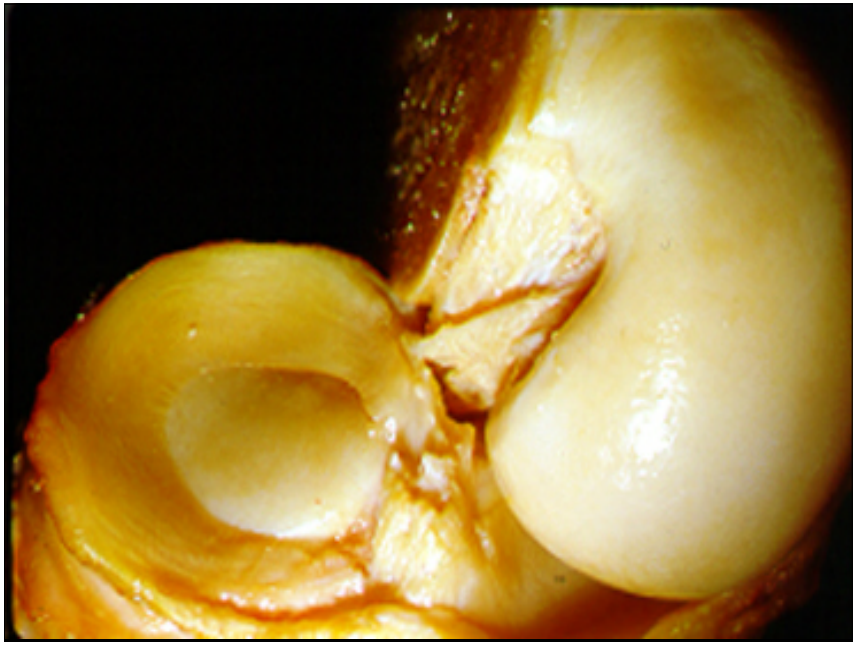


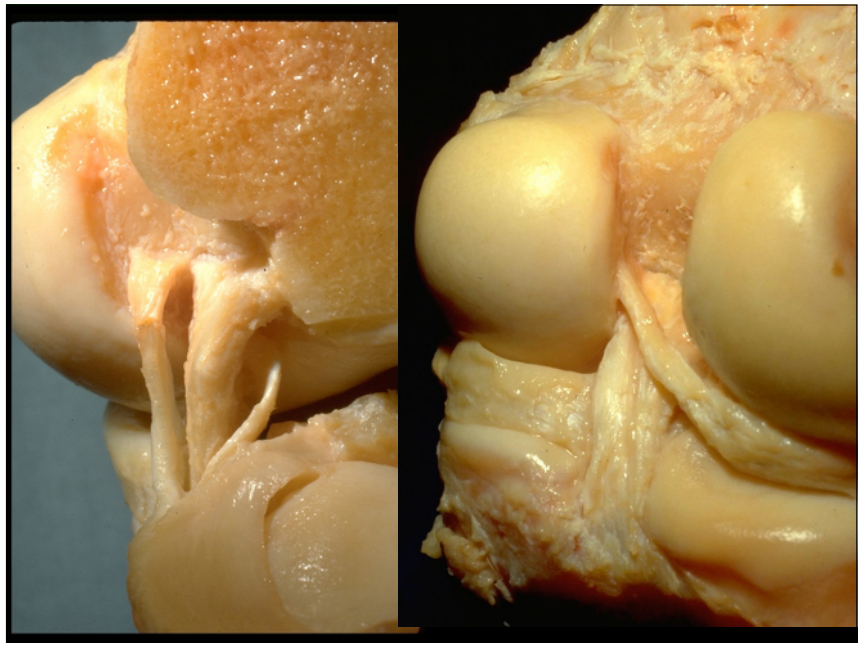

ERA
PERIOD
LUNG FISH
AMPHIBIANS
REPTILES
AVIANS
MAMMALS
Millions of Years Ago
CENOZOIC
MESOZOIC
QUAT.
TERTIARY
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
CARBONIFEROUS
DEVONIAN
1
70
135
180
215
260
340
390
Lungfishes
Labyrinthodontia
Crocodilians
Galliformes
Marsupials
Cetaceans
Ungulates
Carnivores
Primates
Saurischian Dinosaurs
Thecodonts
Pelycosaurs
Eryops
Ichthyostegalians

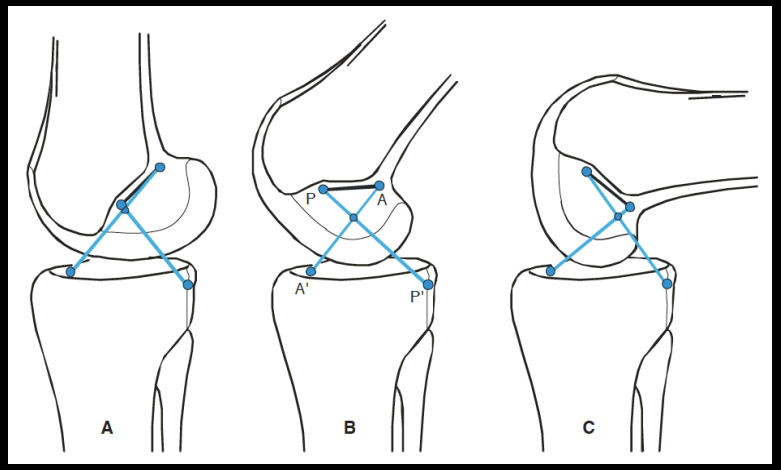

Frog
Human
Sheep
20mm
20mm


Werner Müller
The Knee
Form, Function, and
Ligament Reconstruction
Springer-Verlag
Berlin Heidelberg
New York

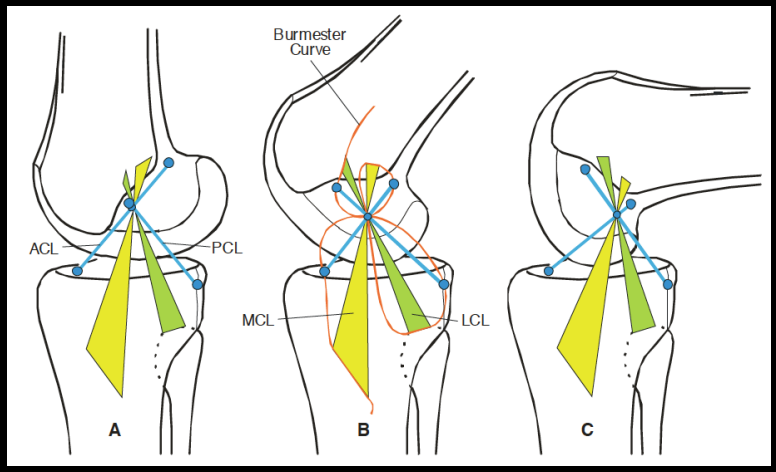








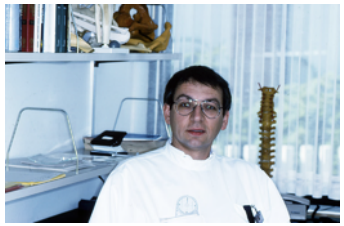
Crossed four-bar linkage



Burmester-curve: MCL, LCL

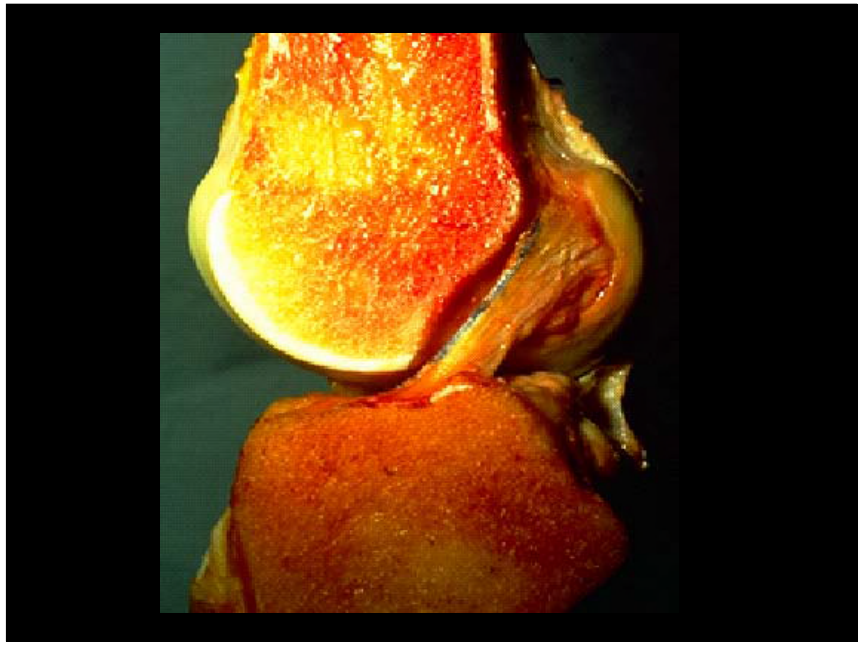
The Knee

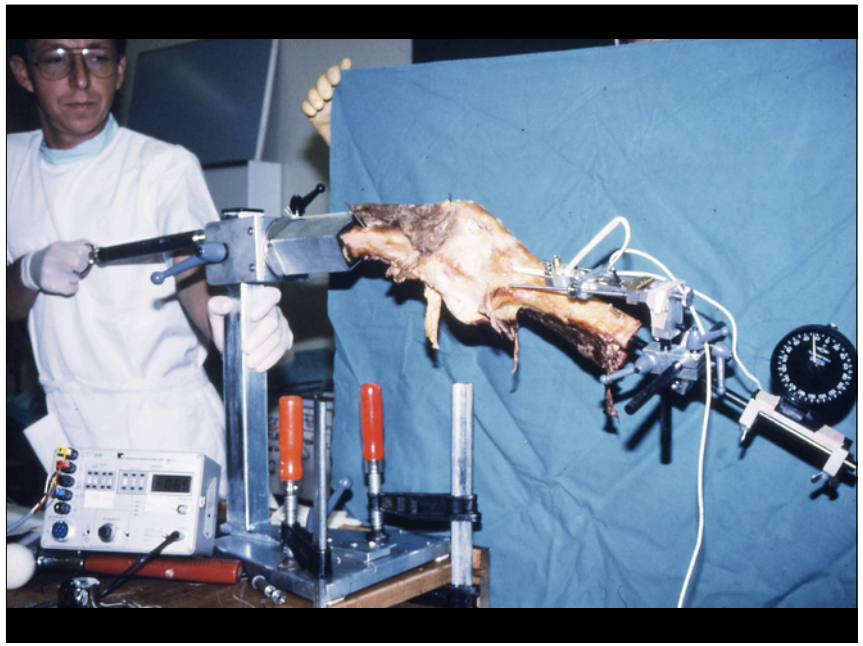
Stepless transmission ?



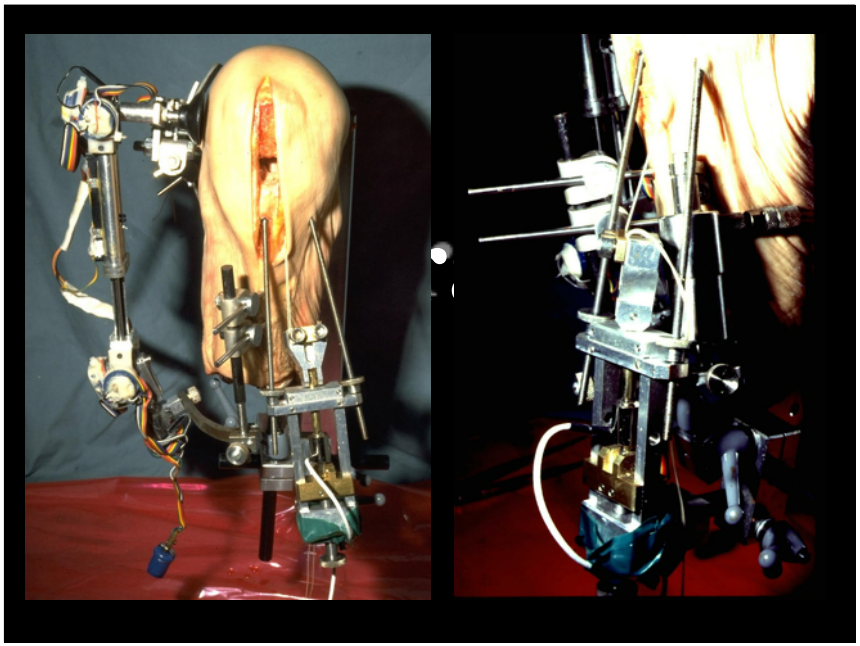
The ‚golden' eighties
(1986-89)

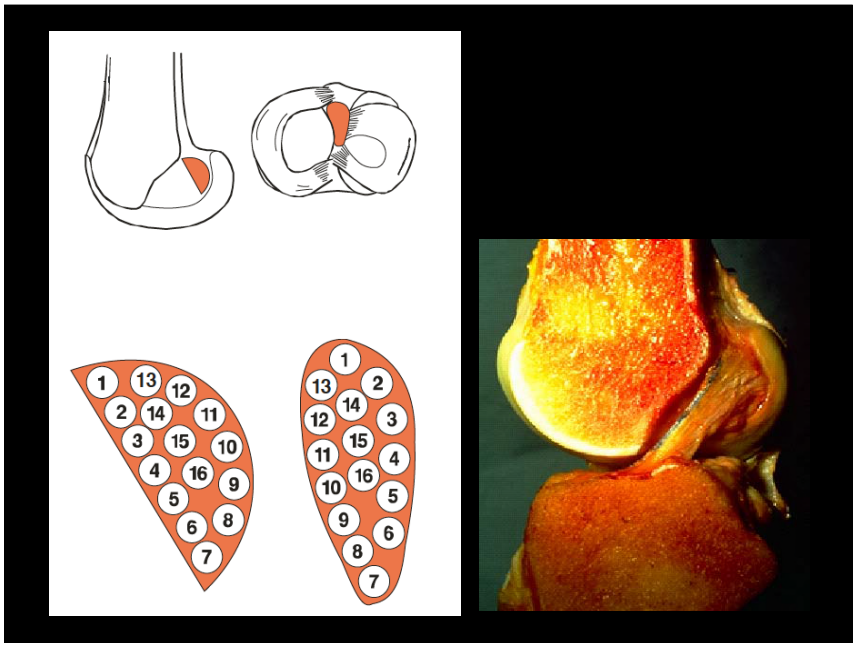
Niklaus Friederich, Victor Tiegermann,
Stefan Freudiger at Kantonsspital Bruderholz



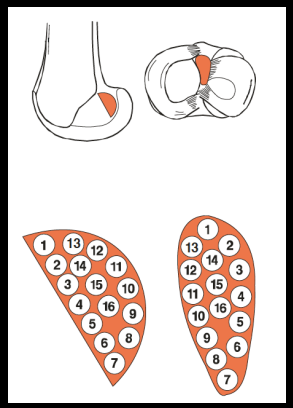


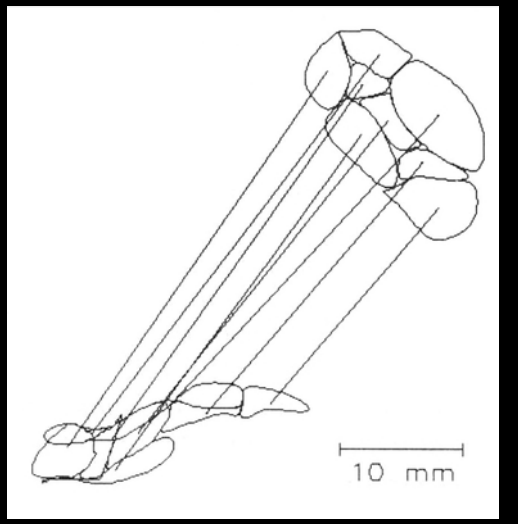
ACL-femoral, movie 1 (1988)

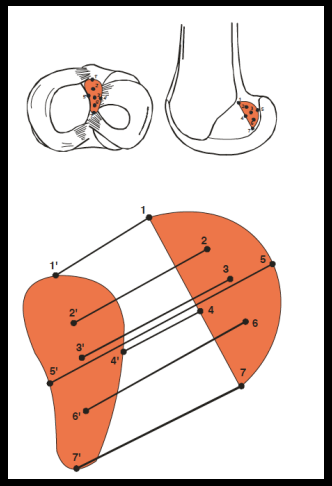


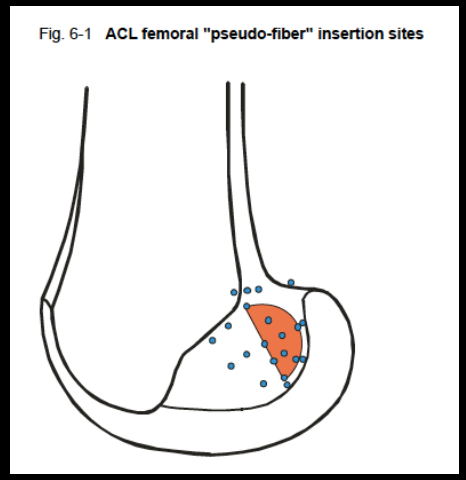


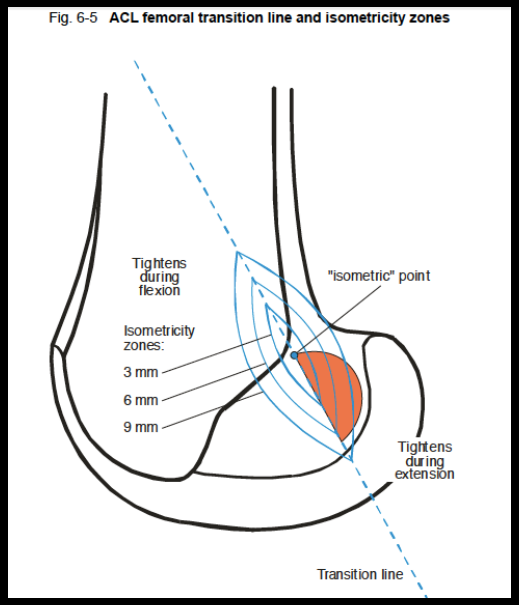
- **D. Mommersteeg, Thesis Nijmegen 1994**

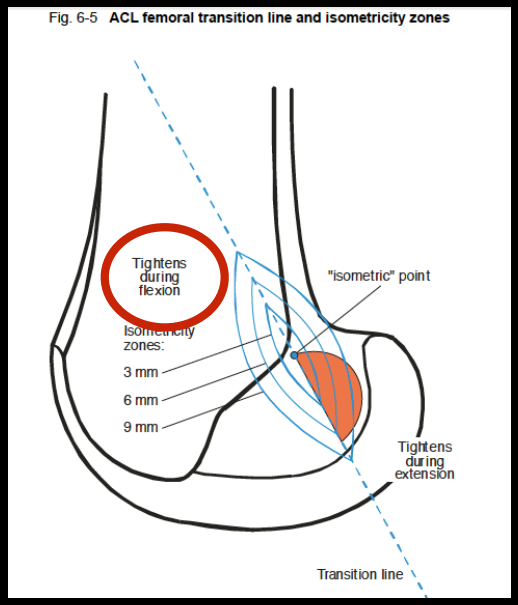












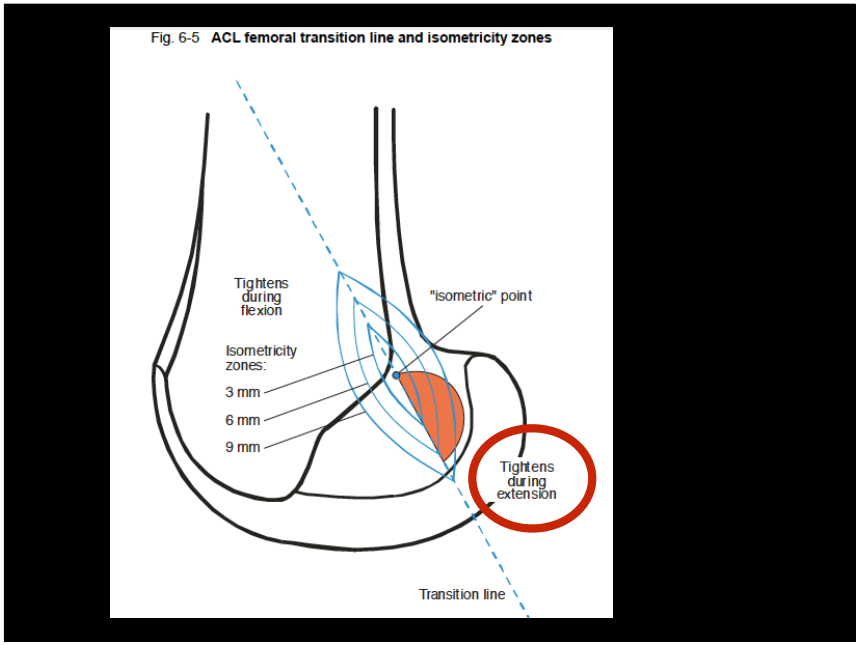
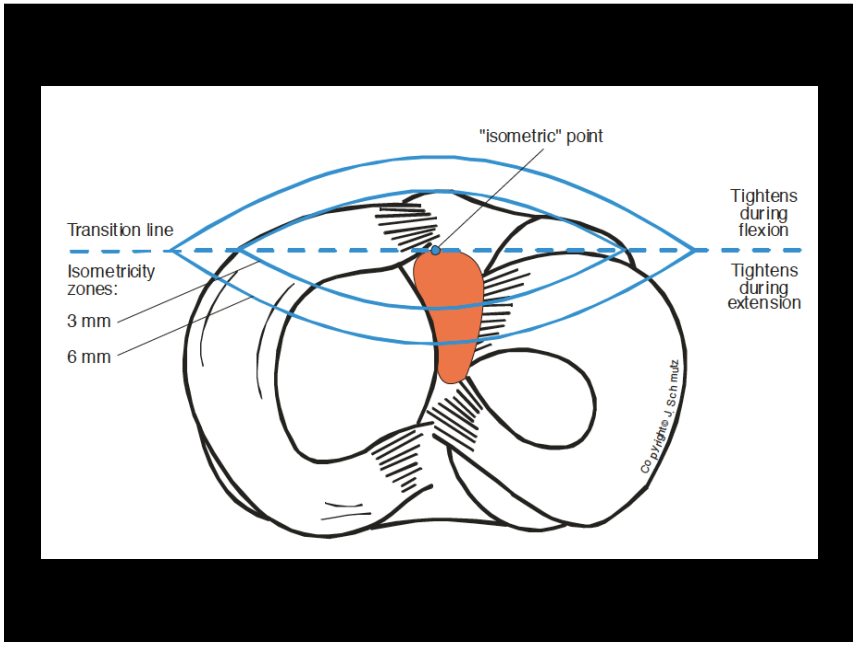
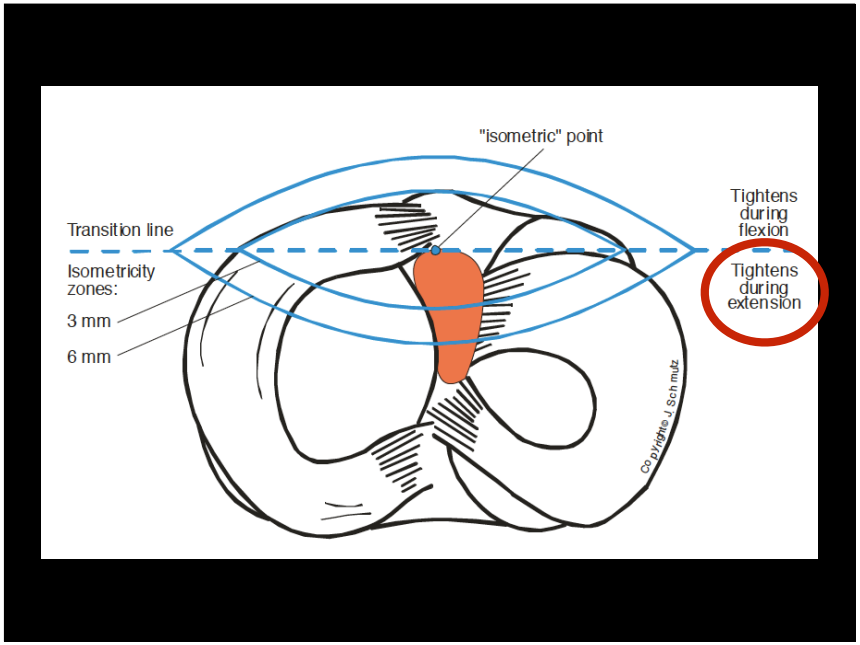


Fig. 6-5 ACL femoral transition line and isometricity zones
Tightens during flexion
"isometric" point
Isometricity zones:
3 mm
6 mm
9 mm
Tightens during extension
Transition line


"isometric" point
Transition line
Isometricity zones:
3 mm
6 mm
Tightens during flexion
Tightens during extension
Copyright J Sch mutz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Tightens during flexion
Tightens during extension
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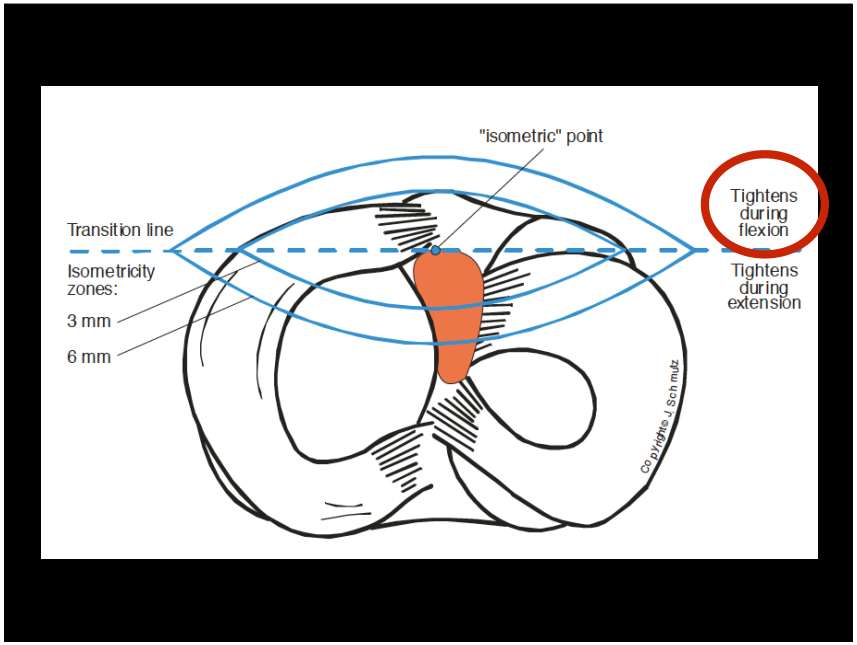
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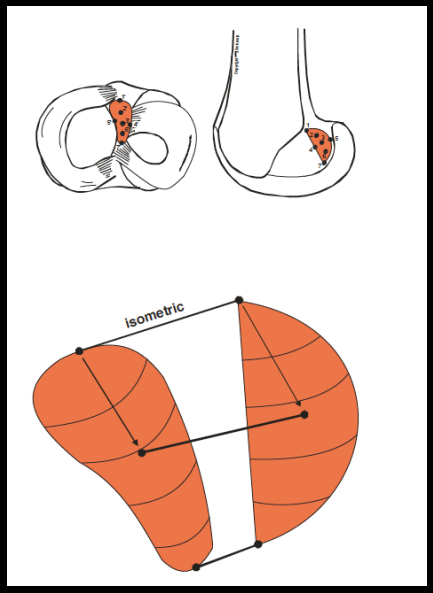
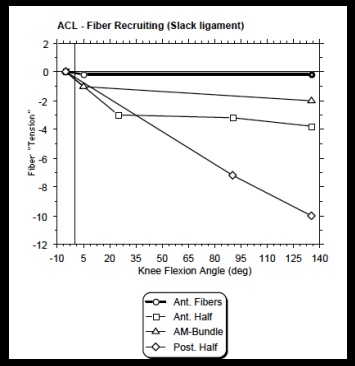
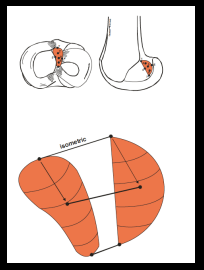


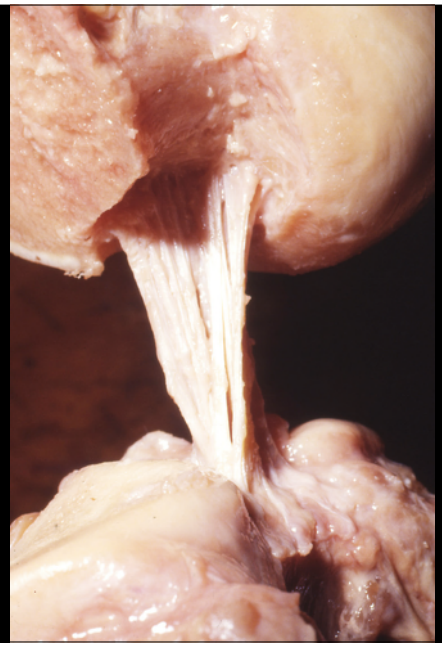


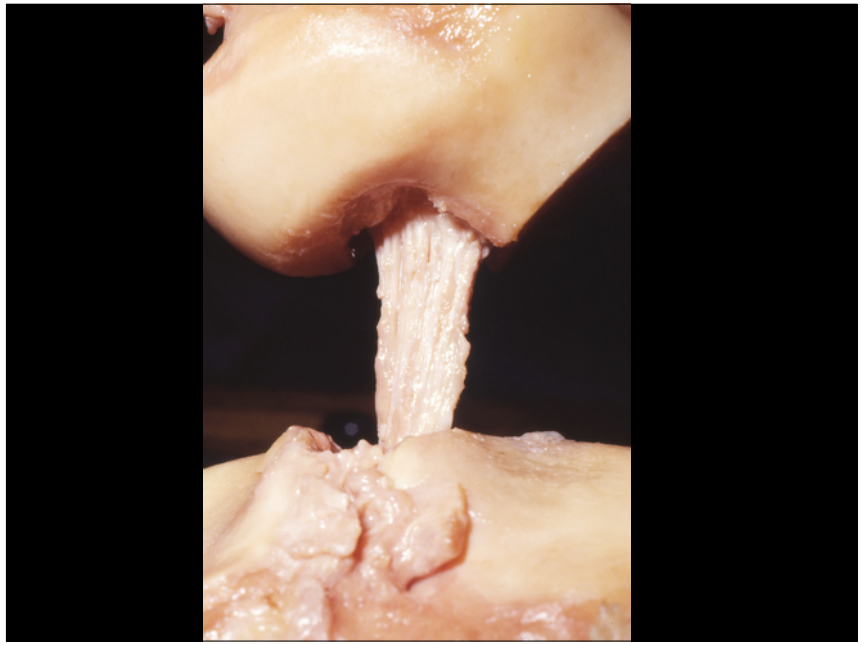
Progressive recruiting of fibers

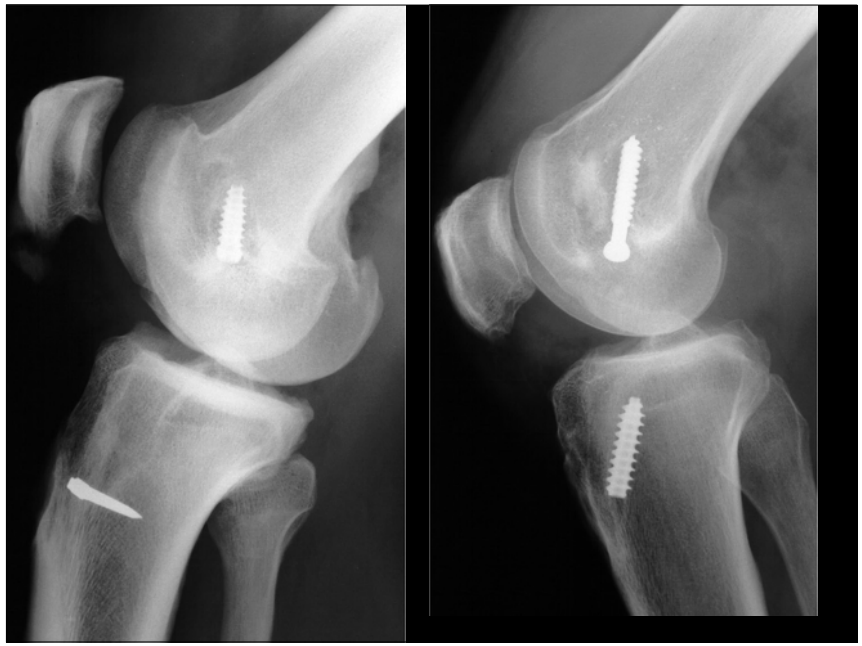
ACL-femoral, movie 2 (1988)



Currently very detailed anatomical studies by Robert Smiglieski, Poland and Rainer Siebold, Germany come to the same results



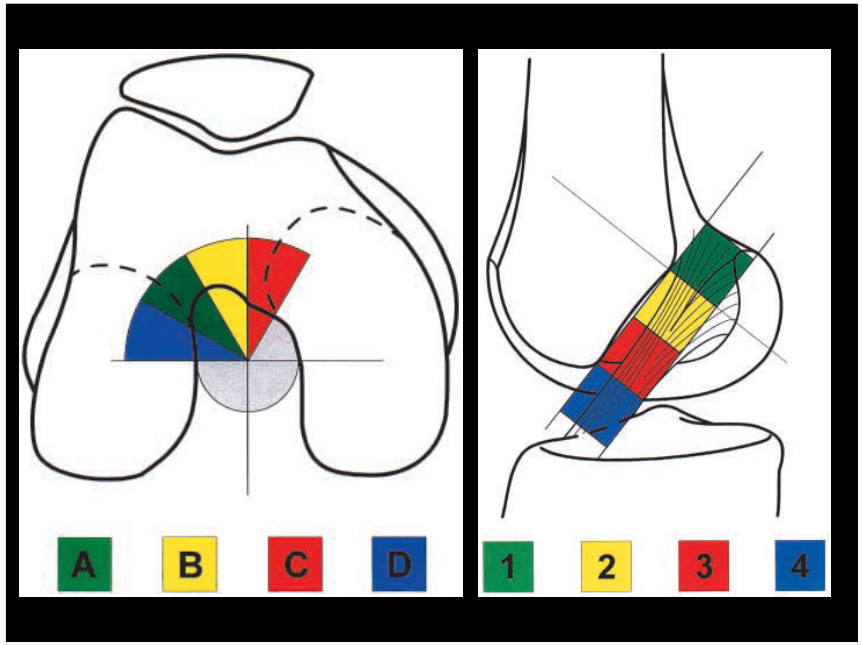


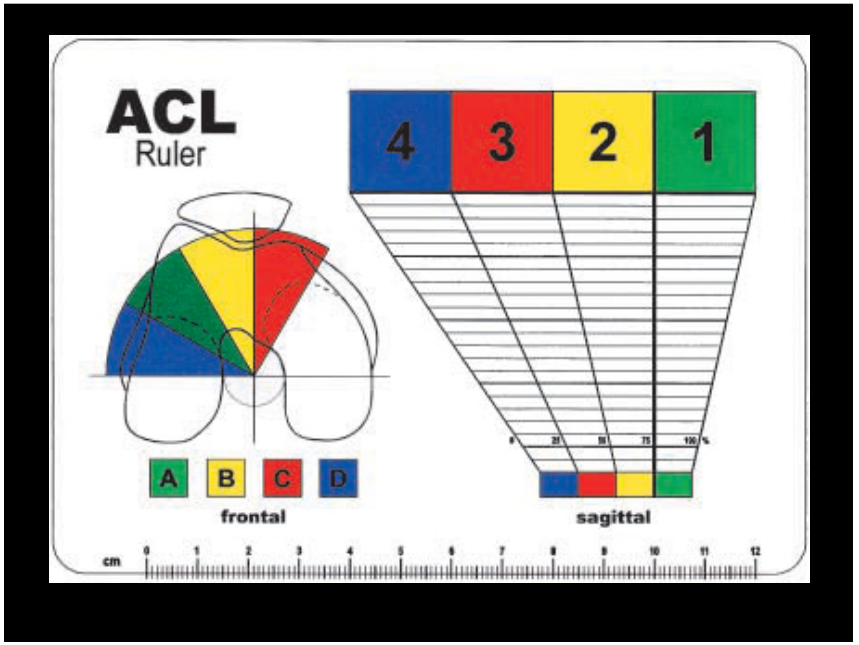


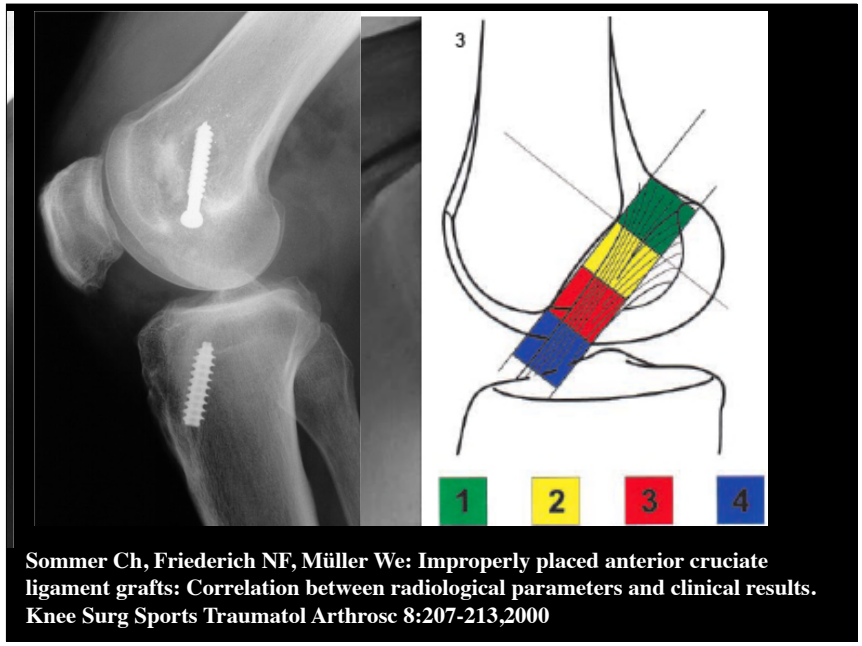
Christian Sommer
Niklaus F. Friederich
Werner Müller

Improperly placed anterior cruciate ligament grafts: correlation between radiological parameters and clinical results

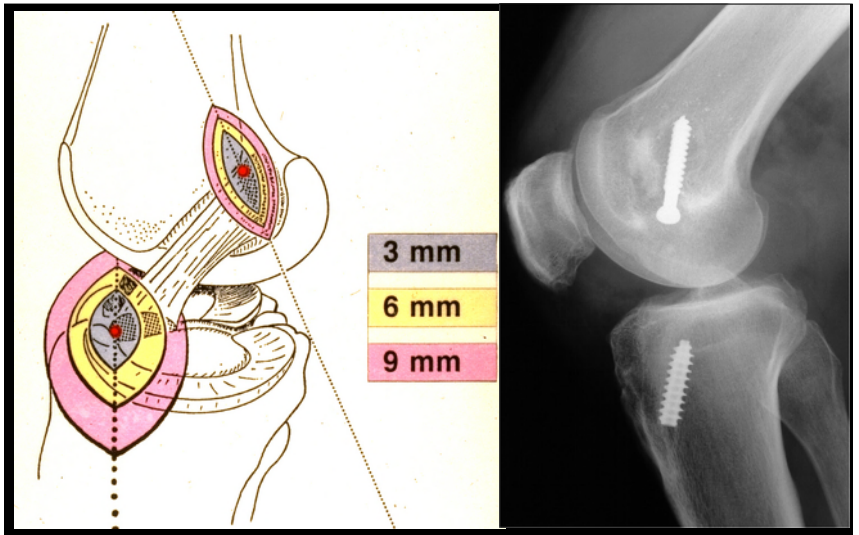
Knee Surg, Sports Traumatol, Arthrosc
(2000) 8 : 207–213





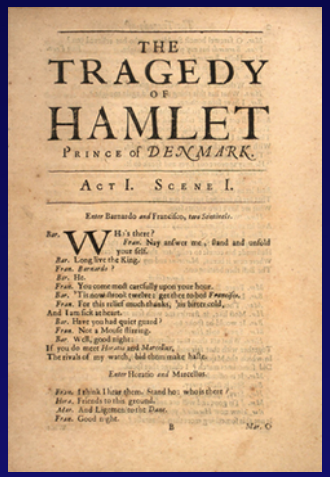


Sommer Ch, Friederich NF, Müller We: Improperly placed anterior cruciate ligament grafts: Correlation between radiological parameters and clinical results. Knee Surg Sports Traumatol Arthrosc 8:207-213,2000



Sommer Ch, Friederich NF, Müller We: Improperly placed anterior cruciate ligament grafts: correlation between radiological parameters and clinical results. Knee Surg Sports Traumatol Arthrosc 8:207-213,2000

To operate or not


THE
TRAGEDY
OF
HAMLET
PRINCE of DENMARK.

ACT I. SCENE I.

Enter Barnardo and Francisco, two Centinels.

Ber. Who's there?

Fran. Nay answer me: stand and unfold your self.

Ber. Long live the King.

Fran. Barnardo?

Ber. He.

Fran. You come most carefully upon your hour.

Ber. 'Tis now strook twelve: get thee to bed Francisco.

Fran. For this relief much thanks: 'tis bitter cold,
And I am sick at heart.

Ber. Have you had quiet guard?

Fran. Not a Mouse stirring.

Ber. Well, good night.
If you do meet Horatio and Marcellus,
The rivals of my watch, bid them make haste.

Enter Horatio and Marcellus.

Fran. I think I hear them. Stand ho: who is there?

Hor. Friends to this ground.

Mar. And Liegemen to the Dane.

Fran. Good night.

B

Mar. C

Curr Rev Musculoskelet Med (2017) 10:322–327
DOI 10.1007/s12178-017-9431-6

ACL REHAB (T SGROI AND J MOLONY, SECTION EDITORS)

Non-operative Care of the Patient with an ACL-Deficient Knee

Mark V. Paterno[1]

Published online: 29 July 2017

Do I Need Surgery for My ACL/PCL Rupture?

Not all patients with a ruptured ACL or PCL need to have surgery to reconstruct it. Some patients are able to retrain the muscles of their knee with physiotherapy to make them strong and co-ordinated enough to compensate for the lack of function of the injured cruciate ligament. In these cases, surgery may not be necessary.

However, if an associated meniscal injury is symptomatic and repair (as opposed to removal) is considered, it may be best to address the cruciate injury at the same time, as this is associated with a higher likelihood of healing of the meniscal repair, and stabilising the knee would make repeat injury to the meniscus less likely.

In some cases, both the ACL may be ruptured as well as there being a strain of the medial collateral ligament (MCL). Frequently, if the MCL injury is mild or moderate it is often better to rehabilitate from the MCL injury over 6-8 weeks, using a brace and physiotherapy, and once this has healed, then the ACL may be addressed surgically. This reduces the chances of developing post-operative stiffness.

Knee Surg Sports Traumatol Arthrosc (2017) 25:493–500
DOI 10.1007/s00167-016-4172-4

KNEE

Long-term follow-up of isolated ACL tears treated without ligament reconstruction

Thomas L. Sanders[1] · Ayoosh Pareek[1] · Hilal Maradit Kremers[1,2] · Andrew J. Bryan[1] · Bruce A. Levy[1] · Michael J. Stuart[1] · Diane L. Dahm[1] · Aaron J. Krych[1]

Conclusions Patients treated non-operatively after isolated ACL tears are at a significantly higher risk of secondary meniscal tears, arthritis, and TKA when compared to age and sex-matched subjects without ACL tears. Additionally, baseline lateral meniscal tears were significantly associated with an increased probability of developing arthritis and the need for TKA. This information may be helpful when counselling patients about the natural history of ACL tears treated without ligament reconstruction.
Level of evidence III.

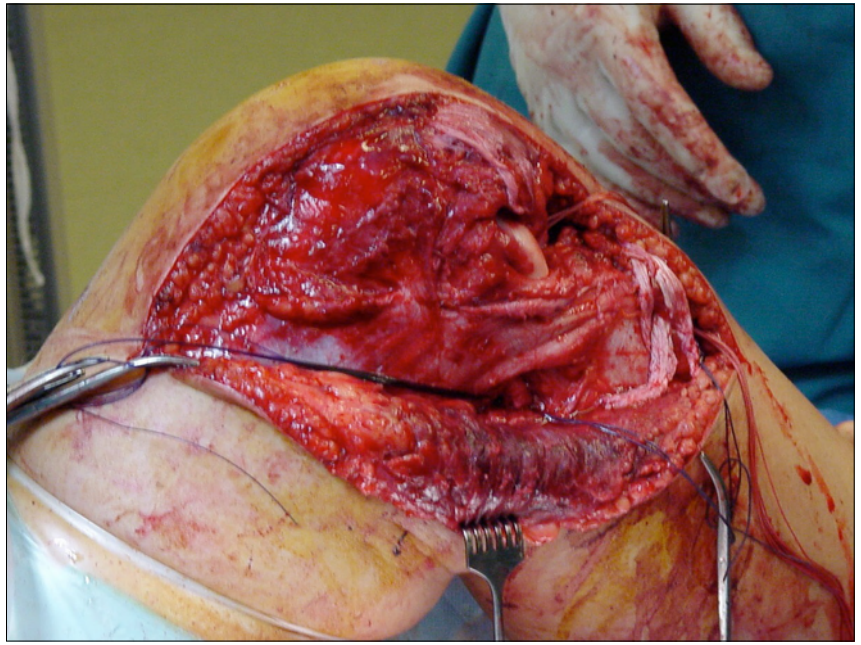
Do surgical techniques matter?

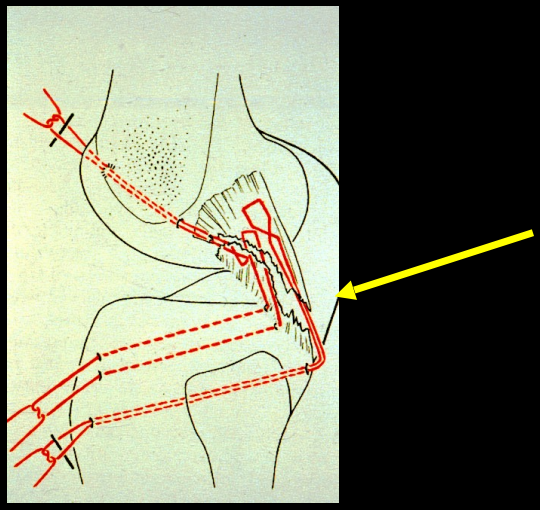
Do surgical techniques matter?

till the 1980's

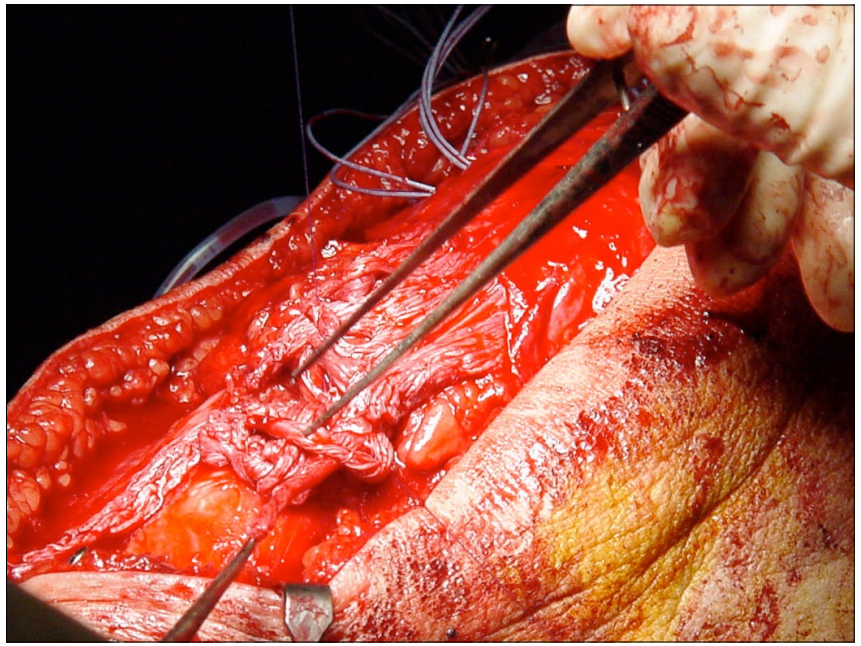
Open surgical techniques:

- Sutures of torn ligaments (augmented, i.e. silk)
- Replacement with iliotibial band, bone-patellar tendon-bone, later on with synthetics (Carbon, Gore-tex®, Dacron, etc)





Martinek V, Steinbacher G, Friederich NF, Müller We: Combined ACL and PC Injuries. Should the Cruciates be preserved? Am J Knee Surgery 13(2):74-82, 2000



Do surgical techniques matter?

till the 1980's

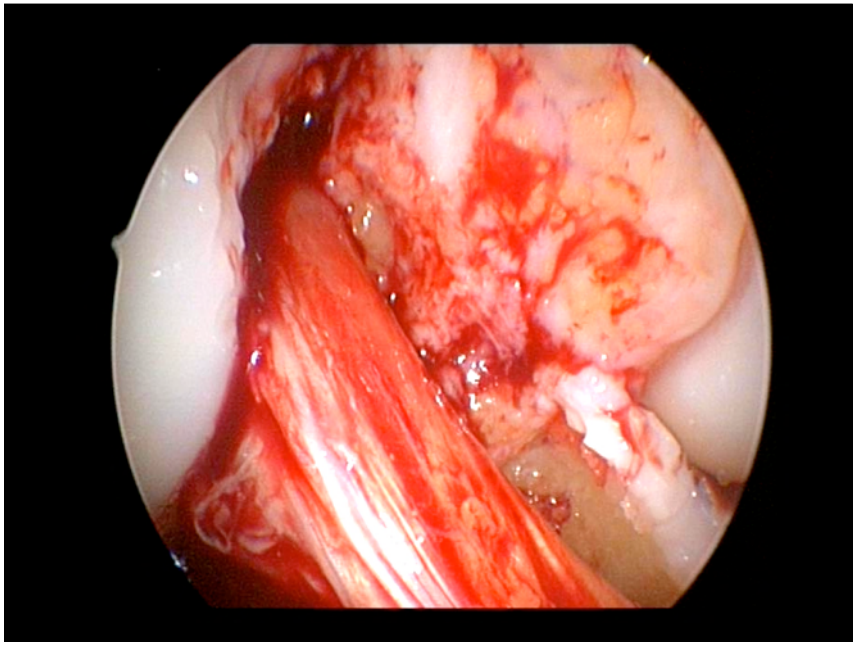
Open surgical techniques:
- Published success rate: about 80%

Do surgical techniques matter?

Do surgical techniques matter?

After 1980

Arthroscopic surgical techniques:
- Replacement with iliotibial band, bone-patellar tendon-bone, **hamstrings**



Do surgical techniques matter?

After 1980

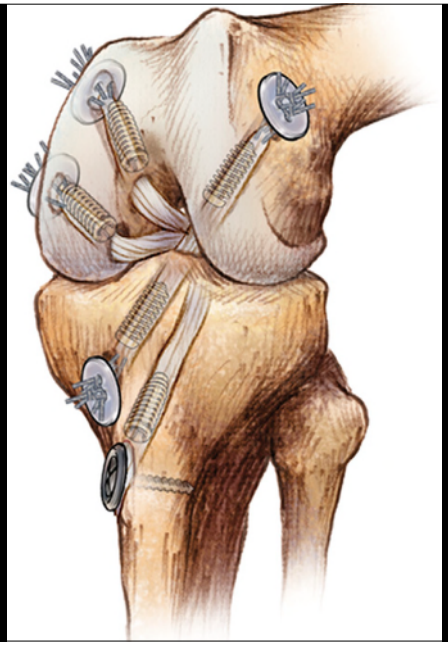
Arthroscopic surgical techniques:
- Published success rate: **about 80%-90%**
- Becomes big volume surgery worldwide

Do surgical techniques matter?

Do surgical techniques matter?

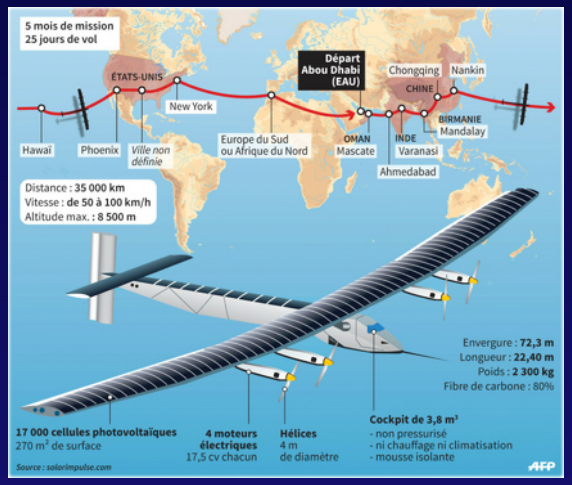
After 1980

Arthroscopic surgical techniques:
- Standardized, **very fast -> 20' - 30'**
- **Very expensive single use instruments**



Fanelli et al:
J Bone Joint Surg Am 2010

Newer techniques ?



Newer techniques ?

After 2015

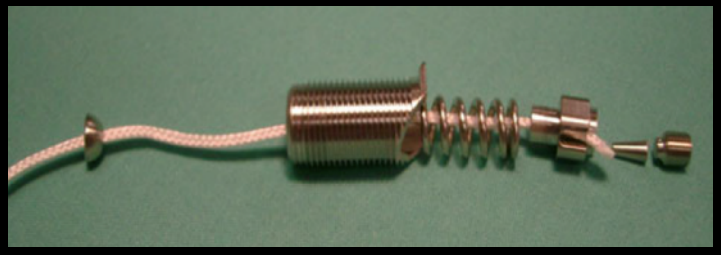
'Biologic/Biotech approach': Sutures, augmented, stem cells, healing response (Martha Murray, Boston; Savio Woo, Pittsburgh)

Knee Surg Sports Traumatol Arthrosc (2013) 21:599–605
DOI 10.1007/s00167-012-1958-x

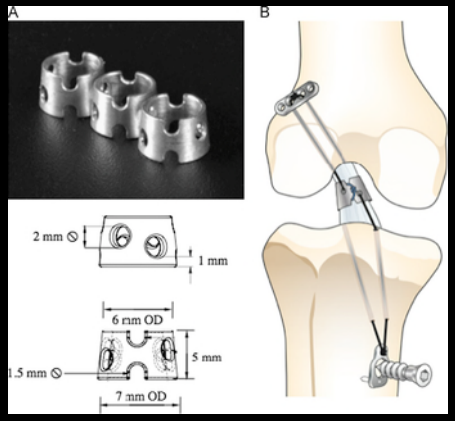
KNEE

Anterior crucial ligament rupture: self-healing through dynamic intraligamentary stabilization technique

Sandro Kohl · Dimitrios S. Evangelopoulos · Hendrik Kohlhof · Max Hartel · Harald Bonel · Phillip Henle · Brigitte von Rechenberg · Stefan Eggli



Mg-based ring with AZ31 alloy



- Bridge the gap / Internal splint
- Degrades with healing
- Cytokines, cells, bioscaffolds
- Based on mid-substance of ACL
- Novel implantation technique

Savio L-Y Woo

Nothing is good or bad, but thinking makes it so.

- William Shakespeare

Which determinants predict tibiofemoral and patellofemoral osteoarthritis after anterior cruciate ligament injury? A systematic review

Belle L van Meer,[1] Duncan E Meuffels,[1] Wilbert A van Eijsden,[1] Jan A N Verhaar,[1] Sita M A Bierma-Zeinstra,[1,2] Max Reijman[1]

Conclusions Medial meniscal injury/meniscectomy after ACL rupture increased the risk of OA development. In contrast, it seems that lateral meniscal injury/ meniscectomy has no relationship with OA development. Our results suggest that time between injury and reconstruction does not influence patellofemoral and tibiofemoral OA development. Many determinants showed conflicting and limited evidence and no determinant showed strong evidence.

1 Orthop. Universitätsklinik, Felix-Platter-Spital, Basel
2 11600 Wilshire Blvd., Los Angeles, USA

Gonarthrose nach Verletzung des vorderen Kreuzbandes: Eine Multizenter-, Langzeitstudie

N.F. Friederich[1] und W.R. O'Brien[2]

Zusammenfassung

Um die Arthroseentwicklung nach Verletzung des vorderen Kreuzbandes besser studieren zu können, wurden von vier «Kniezentren» (Hospital for Special Surgery, New York; Orthopädische Klinik, Bruderholz; Orthopaedic and Arthritic Hospital,

Summary

Degenerative Arthritis of the knee following anterior cruciate ligament injury: A multicenter, long-term followup study. In order to estimate incidence, severity and associated factors in the development of the degenerative arthritis of the knee

Z.Unfallchir.Vers.med. 86,81-89,1993

Courtesy of Prof. em. Werner Müller

Critical load cases

ORTHO TRAUMA Bruderholz

Universitätsspital Basel

Nachrichten

Kurzcarver erhöhen Verletzungsgefahr

München. DPA. Mit Kurzski bis zu 1,30 Meter Länge, so genannten Kurzcarvern, steigt für Skifahrer die Gefahr von Unterschenkelbrüchen. Eine Studie in Deutschland hat gezeigt, dass ungeübten Skifahrern mit Kurzcarvern bereits kleine Rillen oder Löcher sowie Raupenspuren in den Skipisten erhebliche Schwierigkeiten bereiten. Nicht selten seien Stürze und schwere Unterschenkelverletzungen die Folge. «Der Kurzcarver ist ein Zweitski für Könner, jedoch nicht für Anfänger und Kinder», heisst es.

Johnson RJ, Ettlinger CF Shealy JE, Meader C:
Impact of super sidecut skis on the epidemiology of skiing injuries
Sportverletz Sportschaden 11(4):150-152,1997

Institut für Sport der Universität Basel

Belastungen beim Carving

Technikanalyse und Kräfte beim Carving

Diplomarbeit zur Erlangung des Eidg. Turn- und Sportlehrerdiploms II

Vorgelegt von:

Alain Dössegger
Heidenlochstr. 43
4410 Liestal

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Thiersteinerstr. 4
4153 Reinach

Betreuer:
PD Dr. Niklaus F. Friederich
Kantonsspital Bruderholz
Klinik für Orthopädie und Traumatologie des Bewegungsapparates
4101 Bruderholz

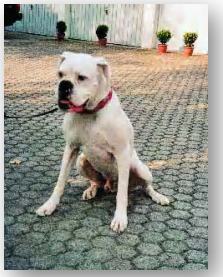
Basel, Sommer 2000

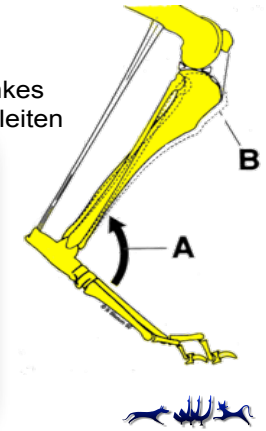
Kniegelenke von Katzen (und Hunden) haben ganz andere Winkel und Hebelarme als wir Menschen – Deshalb auch deutlich mehr Arthrose nach VKB-Ruptur

Diagnose

Tibia - Kompressions Test

- Bei Beugung des Sprunggelenkes kommt es zu einem Vorwärtsgleiten der Tibia.

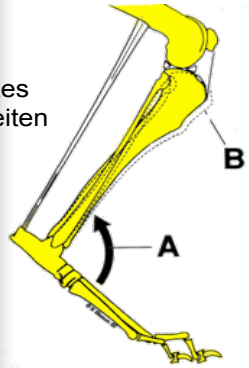




Kreuzband - Osteotomien

l Hunden) haben ganz
e als wir Menschen –
throse nach VKB-Ruptur

kes
leiten



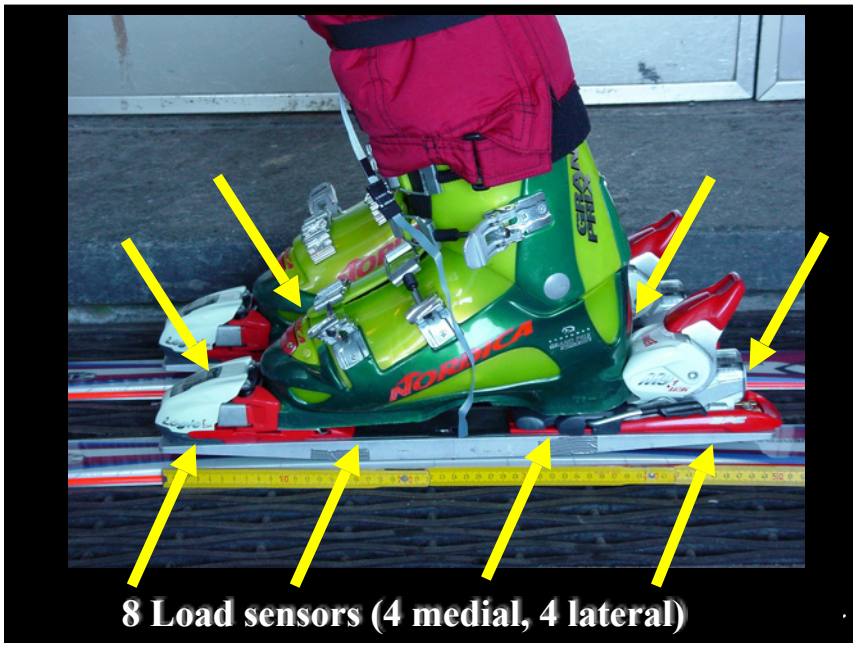
Journal of ASTM International, Vol. 7, No. 8
Paper ID JAI102831
Available online at www.astm.org

Stefan Freudiger,[1] *Wolfgang Vogt,*[2] *and Dieter Wirz*[3]

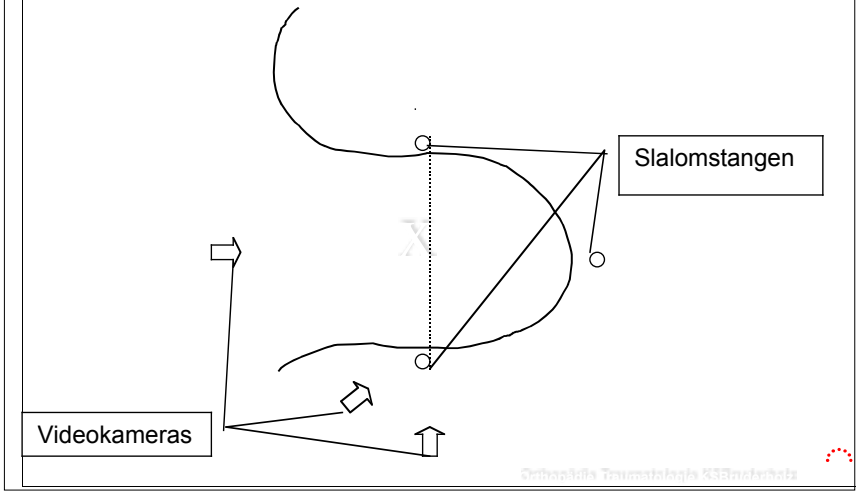
Relative Motion of ACL Insertion Points In Vivo: A Case Study, Including Skiing Maneuvers

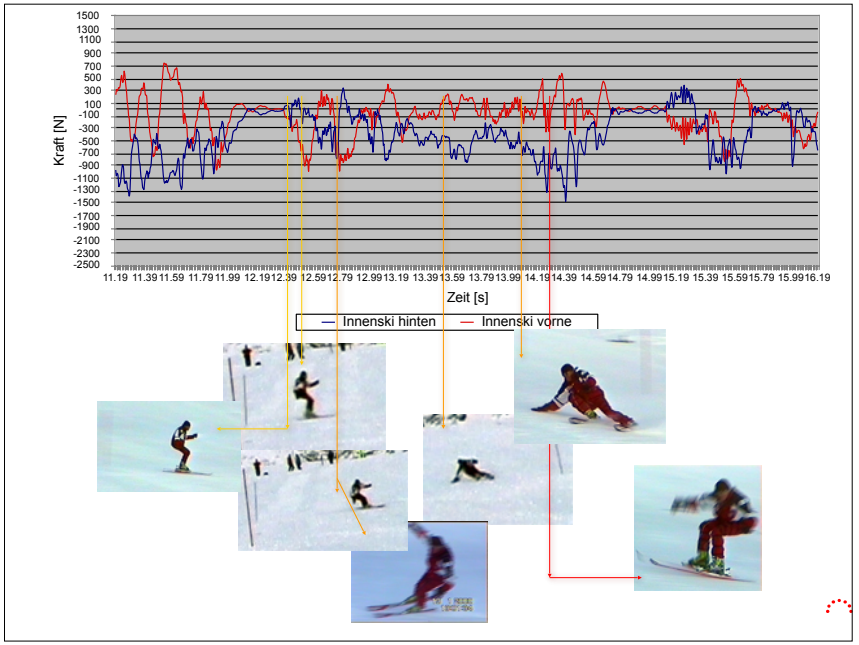
ABSTRACT: FASTRAK receivers were mounted on Kirschner-wires inserted in the distal femur and proximal tibia, respectively. Relative motions of the anterior cruciate ligament (ACL) insertion points were calculated for a hypothesised ACL while diagnostic and skiing load cases were applied to the knee. The highest strains, in descending order were: (i) Lachman test (13.5 %), (ii) 20 N•m internal rotation load (10.6 %) and (iii) latero-medial knee movement (6.4 %). The Lachman-procedure not only produces anterior tibial translation (5.5 mm) but as well internal rotation (10.0°). The medial knee movement produces valgus (2.3°) and external rotation (15.6°), but induces flexion (9.7°) as well, which therefore increases ACL load due to a non physiological instantaneous centre of rotation.

KEYWORDS: anterior cruciate ligament, strain, in vivo, skiing injury mechanism, three-dimensional knee motion


8 Load sensors (4 medial, 4 lateral)

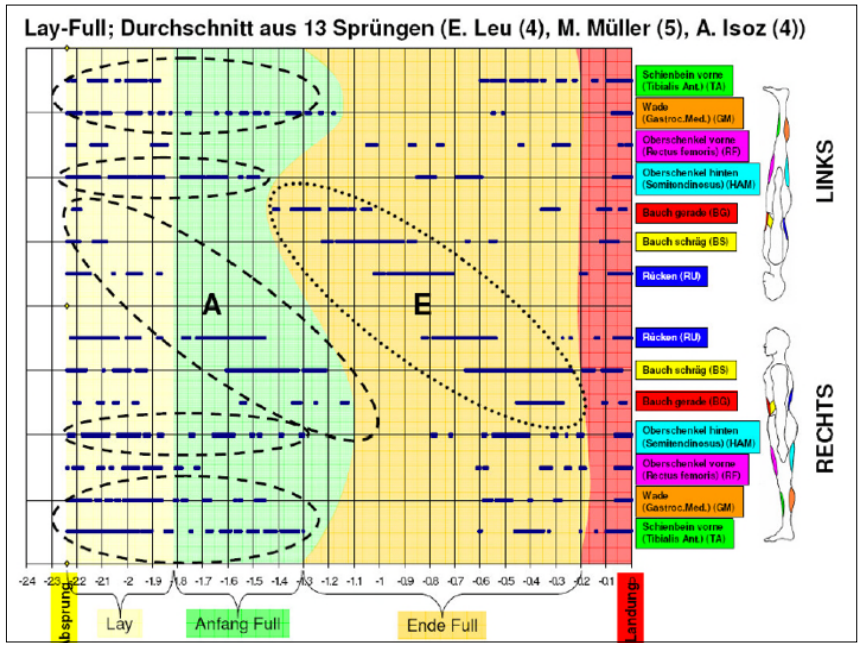
Parcours, Turns, Cameras

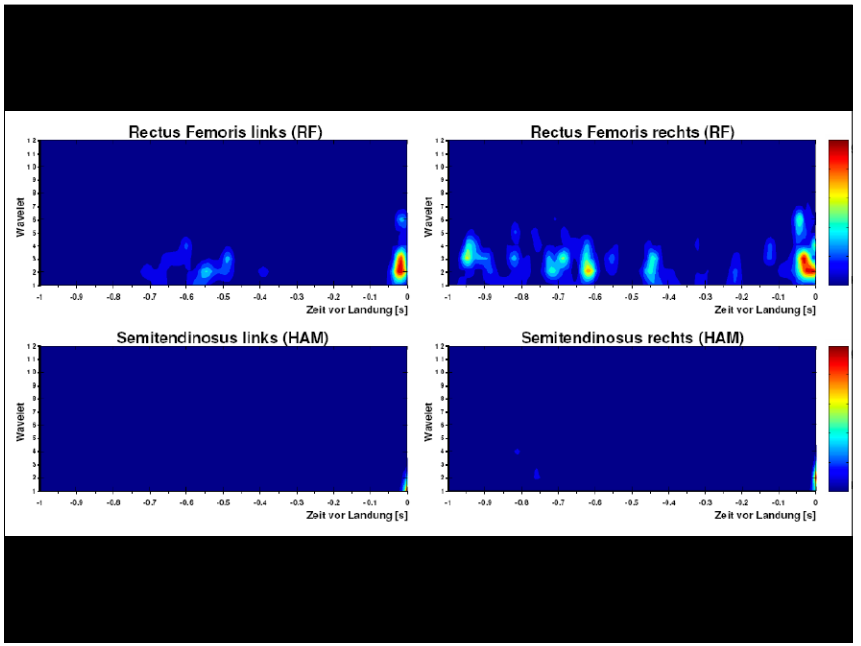




Critical load
‚Hip below Knee‘

Knee loads at acrobatic skiing


Lay-Full; Durchschnitt aus 13 Sprüngen (E. Leu (4), M. Müller (5), A. Isoz (4))
Schienbein vorne (Tibialis Ant.) (TA)
Wade (Gastroc.Med.) (GM)
Oberschenkel vorne (Rectus femoris) (RF)
Oberschenkel hinten (Semitendinosus) (HAM)
Bauch gerade (BG)
Bauch schräg (BS)
Rücken (RU)
LINKS
RECHTS
A
E
-24 -23 -22 -21 -2 -1.9 -1.8 -1.7 -1.6 -1.5 -1.4 -1.3 -1.2 -1.1 -1 -0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1
Absprung
Lay
Anfang Full
Ende Full
Landung


Rectus Femoris links (RF)
Rectus Femoris rechts (RF)
Semitendinosus links (HAM)
Semitendinosus rechts (HAM)
Wavelet
Zeit vor Landung [s]

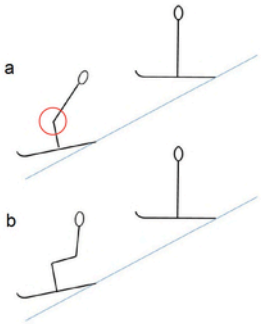
Introduction to

Consensus conference on persisting ACL-lesions at skiing

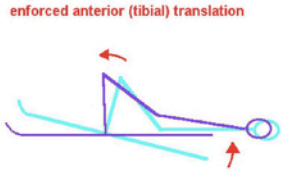
SITEMSH AROSA 2018

Stefan Freudiger
IFB, Bremgarten/BE, Schweiz

Critical load cases for ACL – anterior translation



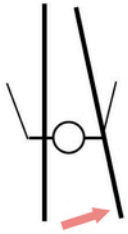
Landing on ski-tails:
a) with locked hip and knee joints
b) with relaxed hip and knee joints



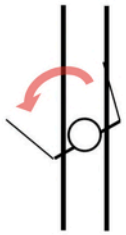
Sliding down the hill with ski suddenly stopped and roll-over of upper body over ski-tails (when ski boots do not allow back to lie on the ski)

Critical load cases for ACL – internal rotation

Right ski-tip went in
= IR (+ varus) in right knee
• moving forward



Right ski-tail went out
= IR (+ valgus) in right knee
• marked backward lean
• moving backward

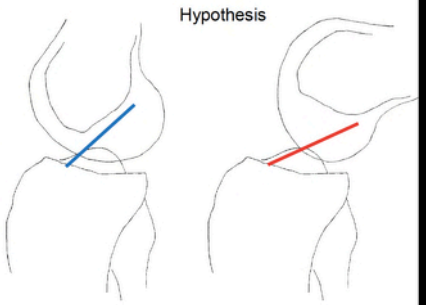


Upper body rotates
(instead of ski)
= pure IR in left knee

Critical load cases for ACL – without fall

Medial edging (ER + valgus) has surprisingly shown to stretch the ACL due to an atypical ICR in the sagittal plane.

Ref: Freudiger, Vogt, Wirz "Relative Motion of ACL Insertion Points In Vivo: A Case Study, Including Skiing Maneuvers" (2010) ASTM Vol 7 No 8



Under high pressure in flexion the femur can no longer slide but starts rolling again, thus additionally stretching the ACL

Compare one-leg-landing of woman handball player

ACL Integrity with Ski Bindings

Richard J. Howell
Howell SkiBindings SM
Stowe, Vermont USA

IOC WORLD CONFERENCE
PREVENTION OF INJURY

16 – 18 MARCH 2017

MONACO

Results:

ACL-rupture *OR* tibia-fracture appear to depend on the *central position* as well as the magnitude of the applied abduction force.