Introduction to

Consensus conference on persisting ACL-lesions at skiing

SITEMSH AROSA 2018

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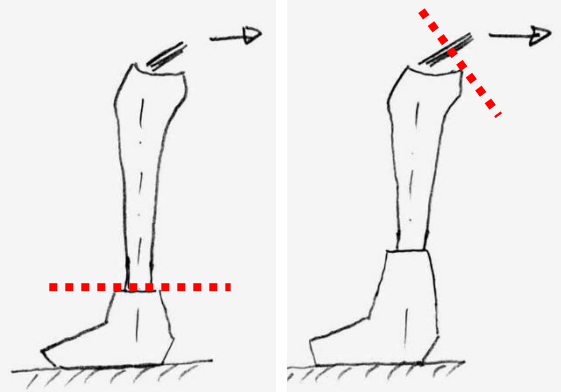
History



Boot height shifted weakest link from tibia to ACL

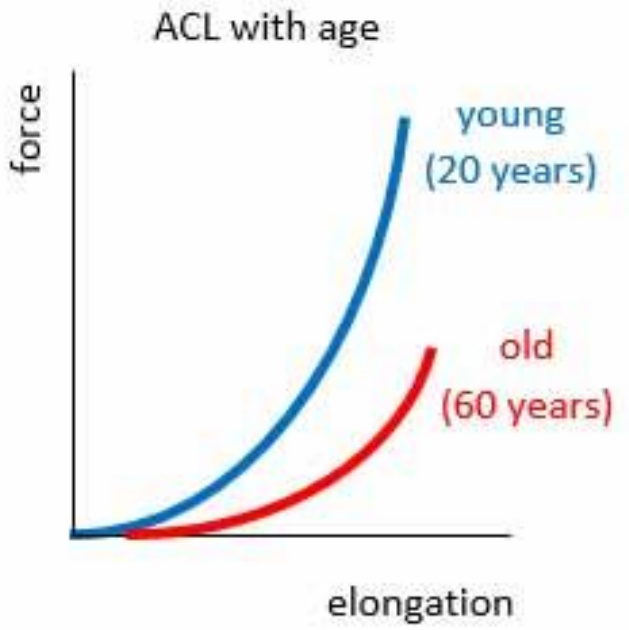
Leather boots absorbed energy missing for release

IR+varus
(typical for inner leg)

ER+valgus
(typical for outer leg)

Abuse of knee joint by immobilization of ankle joint for comfort and control reason

Biomechanics of knee / ACL



Load build-up-time critical for muscle contraction with ACL assistance (synergists). Time threshold roughly estimated to 250 ms.

Remember the LOOK long stroke binding!

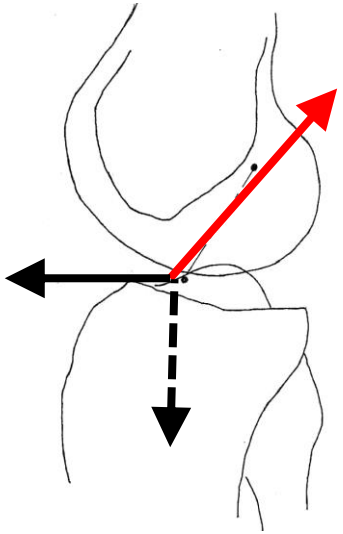
Paresis of rotators (flexors) when extensors are fully contracted (reciprocal innervation)

ref. Phantom-foot
by Carl Ettlinger and Bob Johnson

Injury mechanism for ACL

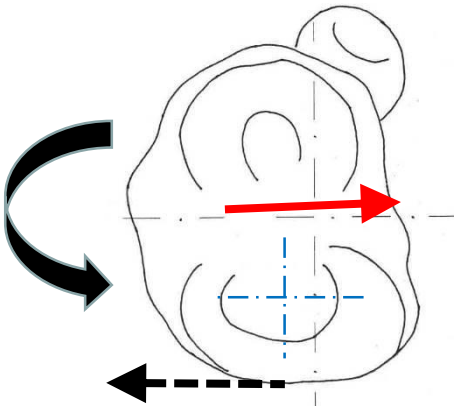
Consensus on anterior tibial translation

at full extension almost no synergist

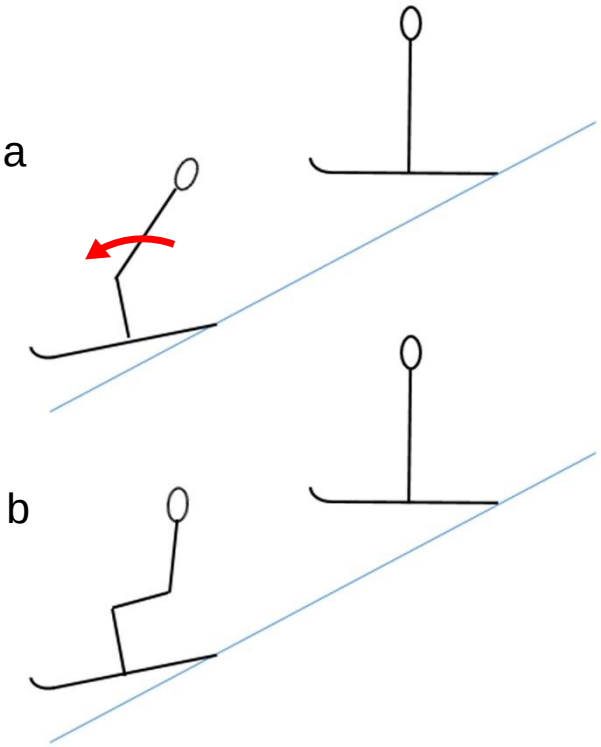


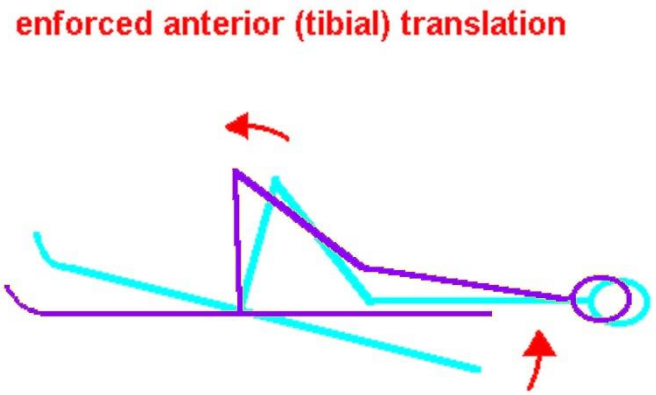
Consensus on internal tibial rotation

possibly augmented by valgus rotation due to inclined lateral tibial plateau



Critical load cases for ACL – anterior translation

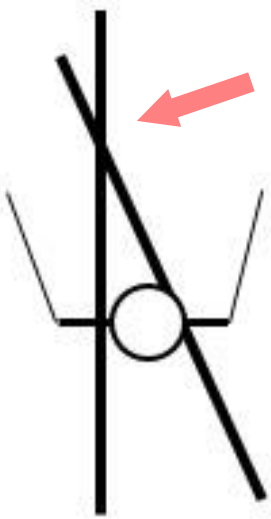




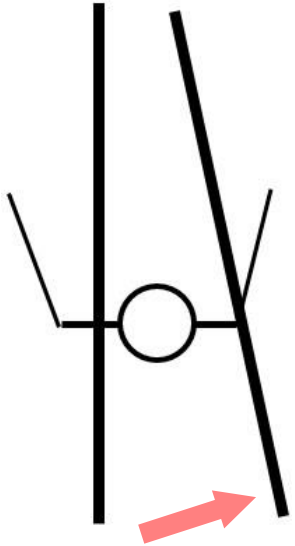
Sliding down the hill with ski suddenly stopped and roll-over of upper body over ski-tails (when ski boots do not allow back to lie on the ski)

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

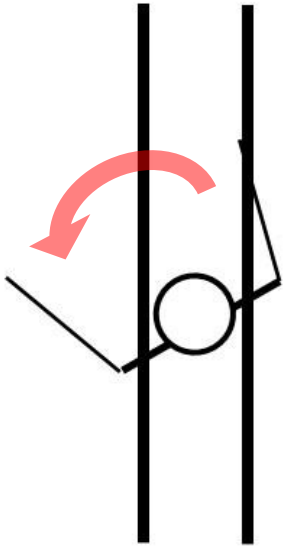
Critical load cases for ACL – internal rotation



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



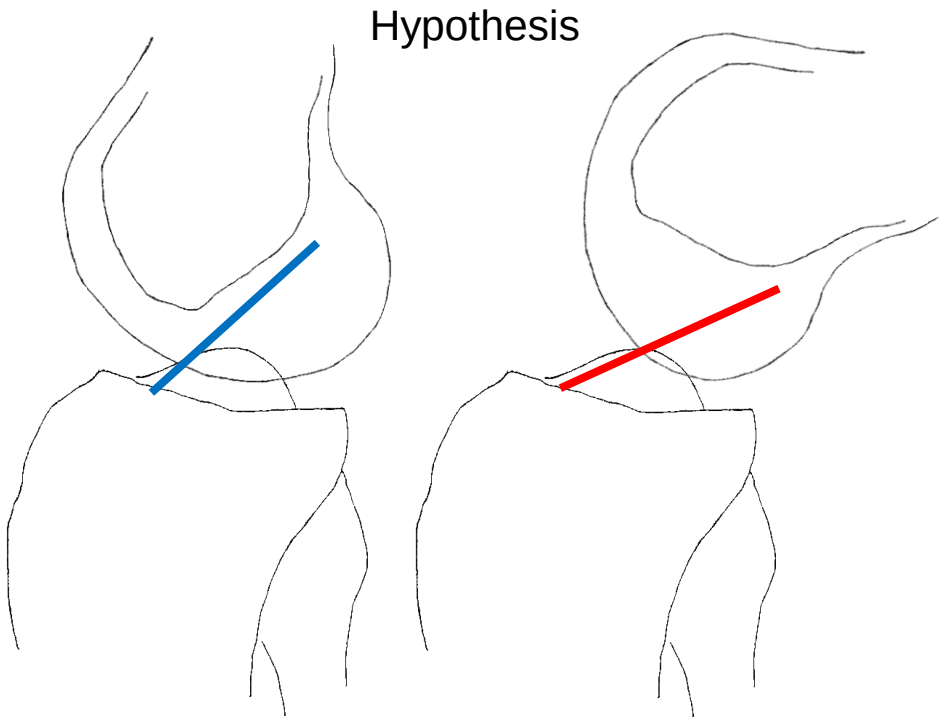
Right ski-tail went out
= IR (+ valgus) in right knee
- marked backward lean
- moving backward



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

Critical load cases for ACL – without fall

Disturbances by grooves in the track



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

Slip + catch maneuver

IR + varus

Neutral rotation at knee joint

Already described by Freudiger and Friederich “Critical load cases for knee ligaments at skiing - an engineering approach” (2001) ASTM STP 1397

Readdressed by Bere et al “Mechanisms of anterior cruciate ligament injury in World Cup alpine skiing: a systematic video analysis of 20 cases” (2011) Am J Sports Med 39/7

But:

IR angle of ski not large enough for injuring an ACL (<30°) ?

Is there an additional loading mechanism, e.g. rolling instead of sliding at high cartilage pressure….

Further analysis on Oslo's slip + catch interpretation

Photos out of of Bere et al

Inward catching skitip produces IR + varus (adduction load)
≠ valgus

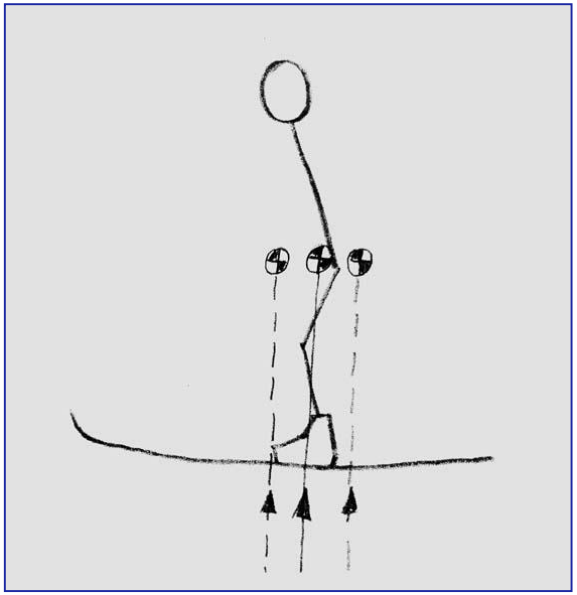
Almost no angular deflection beside flexion

Backward lean without snow splash produces IR + valgus

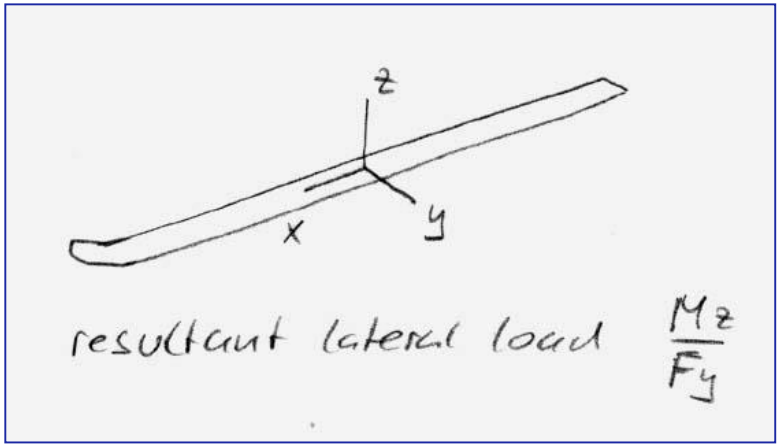
No phantom foot (hip not below knee) !

Conceptual fault of today's ski safety bindings 1/6

Field test measurements have shown that the resultant load at skiing is mostly in the **range of the ski boot** (Maxwell SM and Hull ML 1989, Quinn TP and Mote CD Jr. 1993).



The location of the resultant (lateral) load is determined by dividing Mz through Fy!

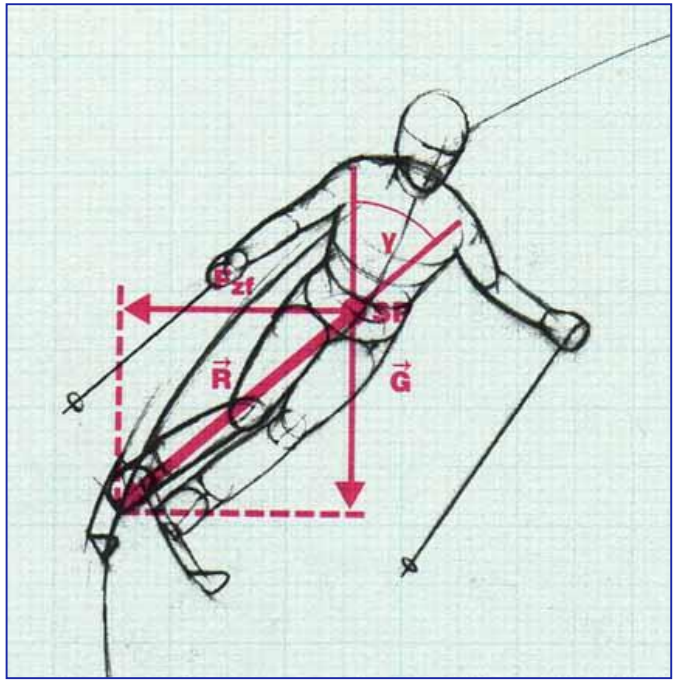


Conceptual fault of today's ski safety bindings 2/6

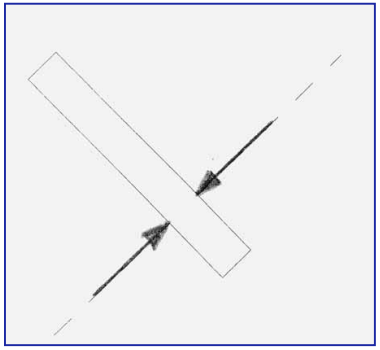
In our own field test (Dössegger A, Kessler U, Freudiger S, Friederich NF 2000) we although measured the resultant load at **extreme carving** to be *slightly forward* of the ski boot at the *entry of the turn* and *slightly rearward* of the ski boot at the *exit of the turn*!

Conceptual fault of today's ski safety bindings 3/6

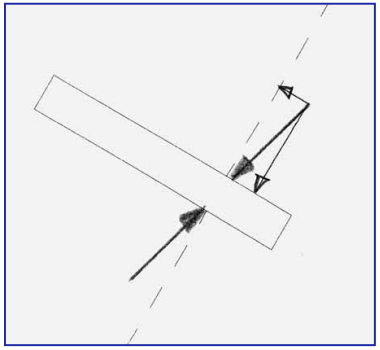
How can a residual side load arise……?



ex SKI SCHWEIZ



right



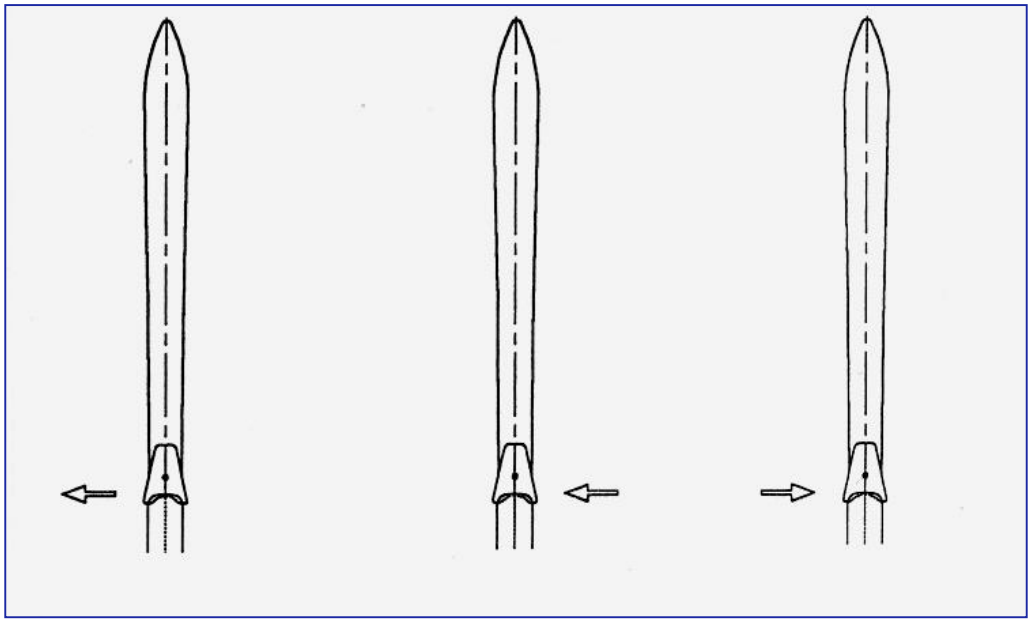
wrong

....when the ski is not properly inclined!

Conceptual fault of today's ski safety bindings 4/6

Can a today's ski safety binding be properly set ?

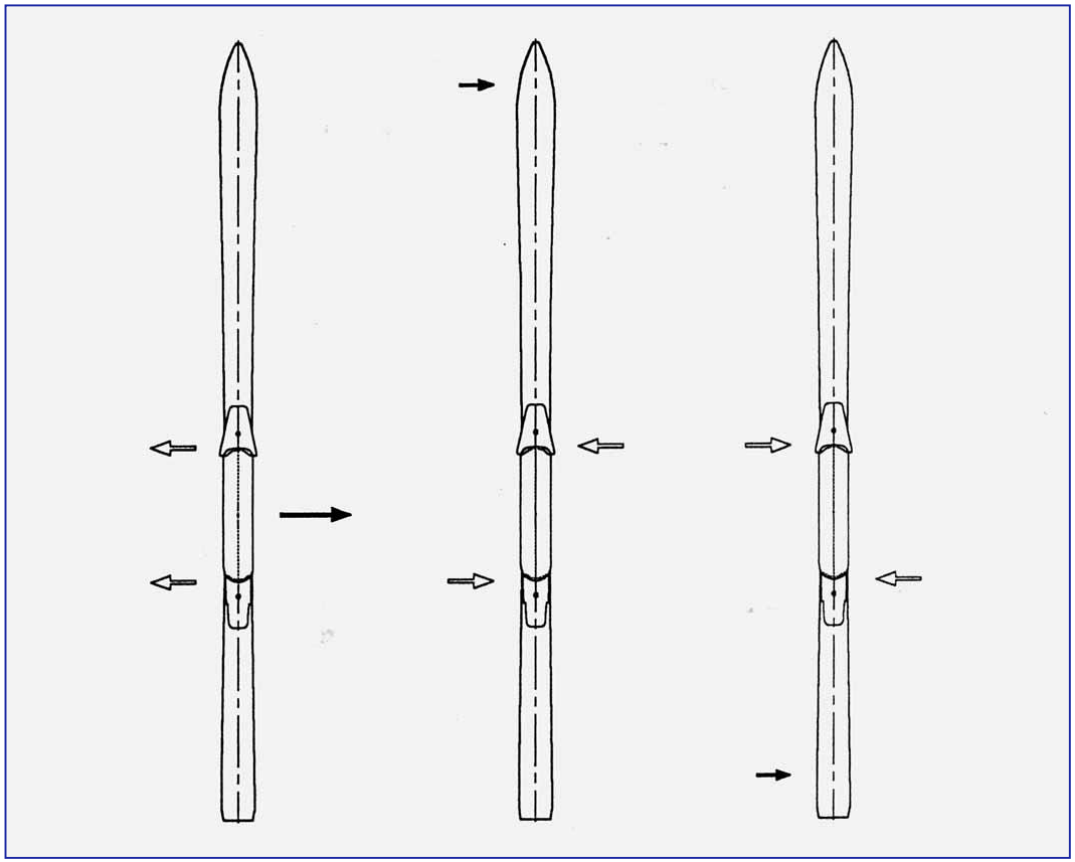
In which case shall the binding **release** to prevent injury ?
In which case shall the binding **retain** to prevent injury ?



It is **impossible** to properly set a today's binding !

In order to avoid inadvertent release the binding must be set **above injury thresholds** !

Conceptual fault of today's ski safety bindings 5/6

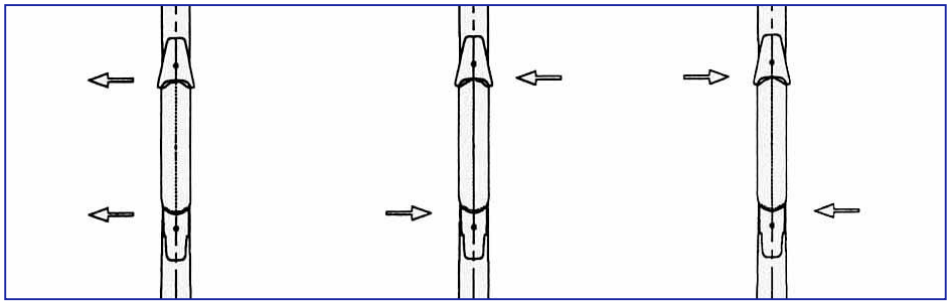


skiing load
no injury potential
no release!

falling load
high injury potential
release!

Conceptual fault of today's ski safety bindings 6/6

One possible solution to this problem:



a b b

The toe and heel piece must communicate:

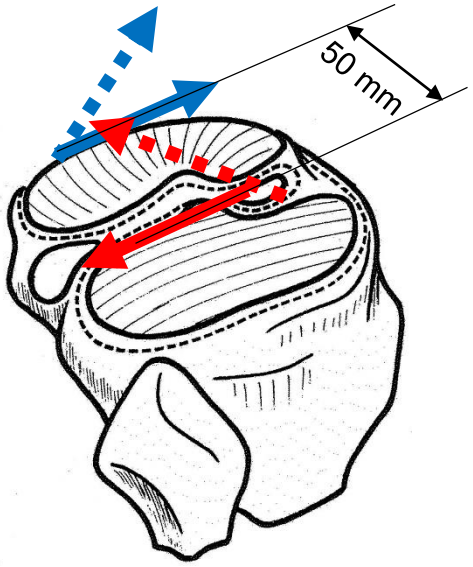
a) If both are loaded to the same direction, the binding shall not release!

b) If they are loaded to opposite directions, the binding shall release before reaching the injury threshold!

Remark: mechanical maintenance-free solutions possible!

Passive release torque (without muscle assistance)

e.g. phantom foot with paralysed rotators
short load build-up time (<< 250 ms)



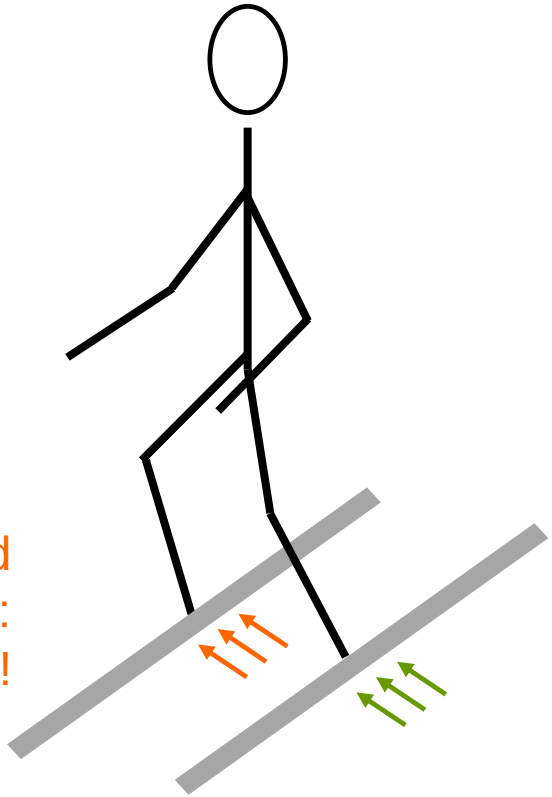
Minimal passive resistance against IR (by ACL and Lcmp)

Age	ACL	Projection	Arm	Moment	Setting
20 y	2’400 N	1’700 N	50 mm	85.0 Nm	8.5
40 y	1’600 N	1’150 N	50 mm	57.5 Nm	5.8
60 y	800 N	570 N	50 mm	28.5 Nm	2.9

Does pure varus- / valgus-load have injury potential ?

Should **pure** valgus-load have injury potential* then: left / right binding !

*) Hip at higher risk than MCL ?
More pain in hip than in knee ?



Pure varus-load should not have injury potential (leg can not deflect) !

No deflection > no strain > no stress !

Pure = without rotation !


Thank you!