Introduction to

Consensus conference on persisting ACL-lesions at skiing

SITEMSH AROSA 2018

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

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

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.


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

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


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

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)!
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 $M_z$ through $F_y$!
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*!
How can a residual side load arise…?

....when the ski is not properly inclined!
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!
One possible solution to this problem:

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)

<table>
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<tr>
<th>Age</th>
<th>ACL</th>
<th>Projection</th>
<th>Arm</th>
<th>Moment</th>
<th>Setting</th>
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<td>1’700 N</td>
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</table>
Does pure varus- / valgus-load have injury potential?

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

No deflection > no strain > no stress!

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 = without rotation!
Thank you!