



Mitigation of ACL injuries and  
inadvertent release  
through better  
ski bindings

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# Objective of this talk

## Education

*it is possible to:*

1. Reduce Inadvertent releases (IR)
2. Reduce ACL injuries
3. Improve transmission of control loads

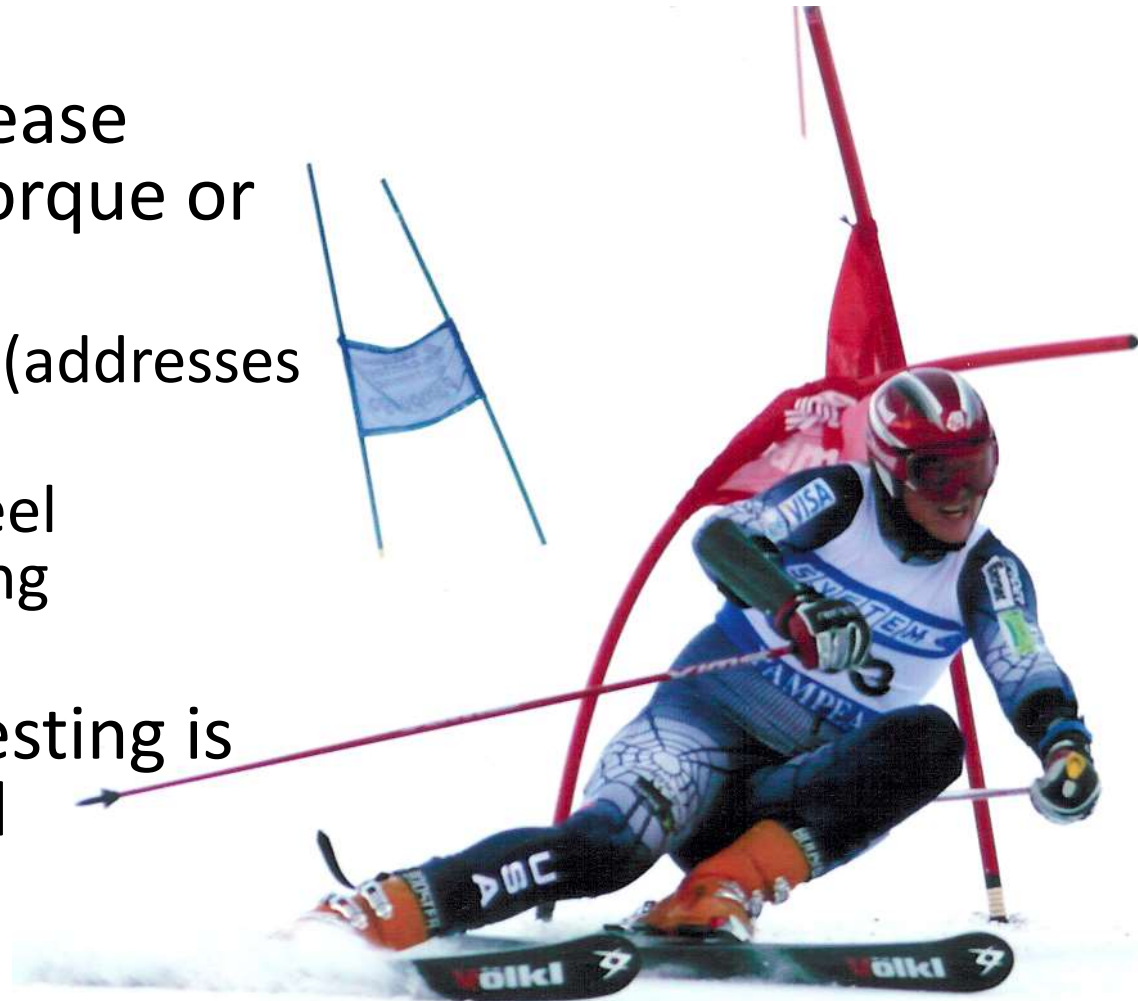
with better bindings and plates.



*There are a number of ways for bindings and plates to do this.*

# State of the Art

- Fundamentally binding technology has changed little since 1980 for most users
- Two modes of release based on loads (torque or moment)
  - Lateral at the toe (addresses spiral fractures)
  - Forward at the heel (addresses bending fractures)
- Current binding testing is mostly load based



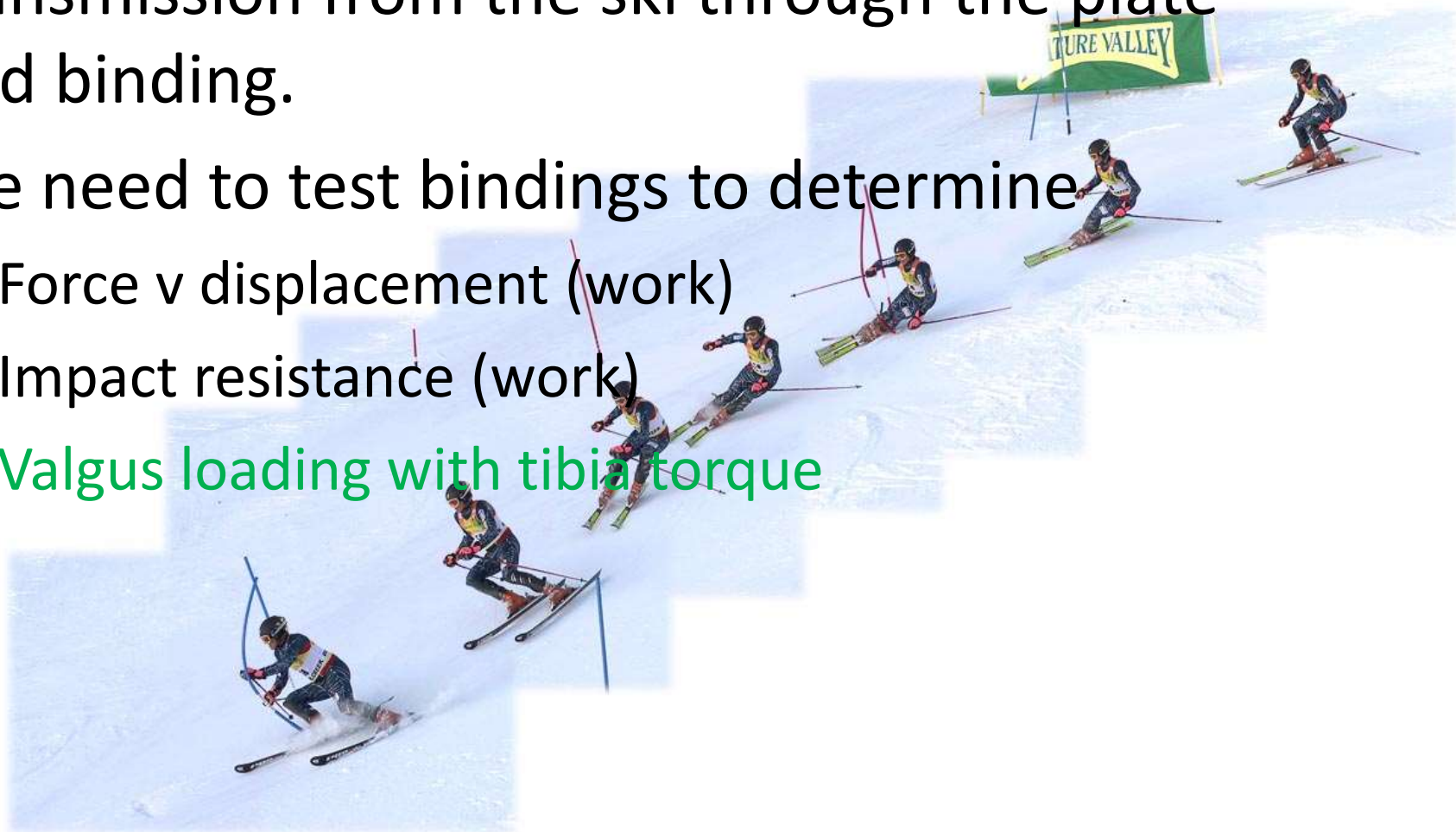
# Approach

- Engineering Mechanics
  - Analysis of loads and displacements
- Engineering Design Theory
  - Define functional requirements
  - Maintain independence of the functions
  - New functions need new features



# The mechanical nature of ACL injuries and IR

- Both relate to loads and to work transmission from the ski through the plate and binding.
- We need to test bindings to determine
  - Force v displacement (work)
  - Impact resistance (work)
  - Valgus loading with tibia torque



# Proposal

- Develop better bindings and plates
- Provide better binding and plate testing
- ***Set up binding testing facilities***
  - ***for IR and ACL related functions***

***“A product can be no better than its testing”***

*Rick Howell*



# State-of-the-art

## IR and binding release settings

- Elevated release settings only apparent means available to reduce IR currently.
- Unintended consequence → increased risk of leg and knee injuries.
- ***Despite elevated settings IR may occur more often than leg and knee injuries in high-level competition***
- ***Release functions are often distrusted especially in high level competition***

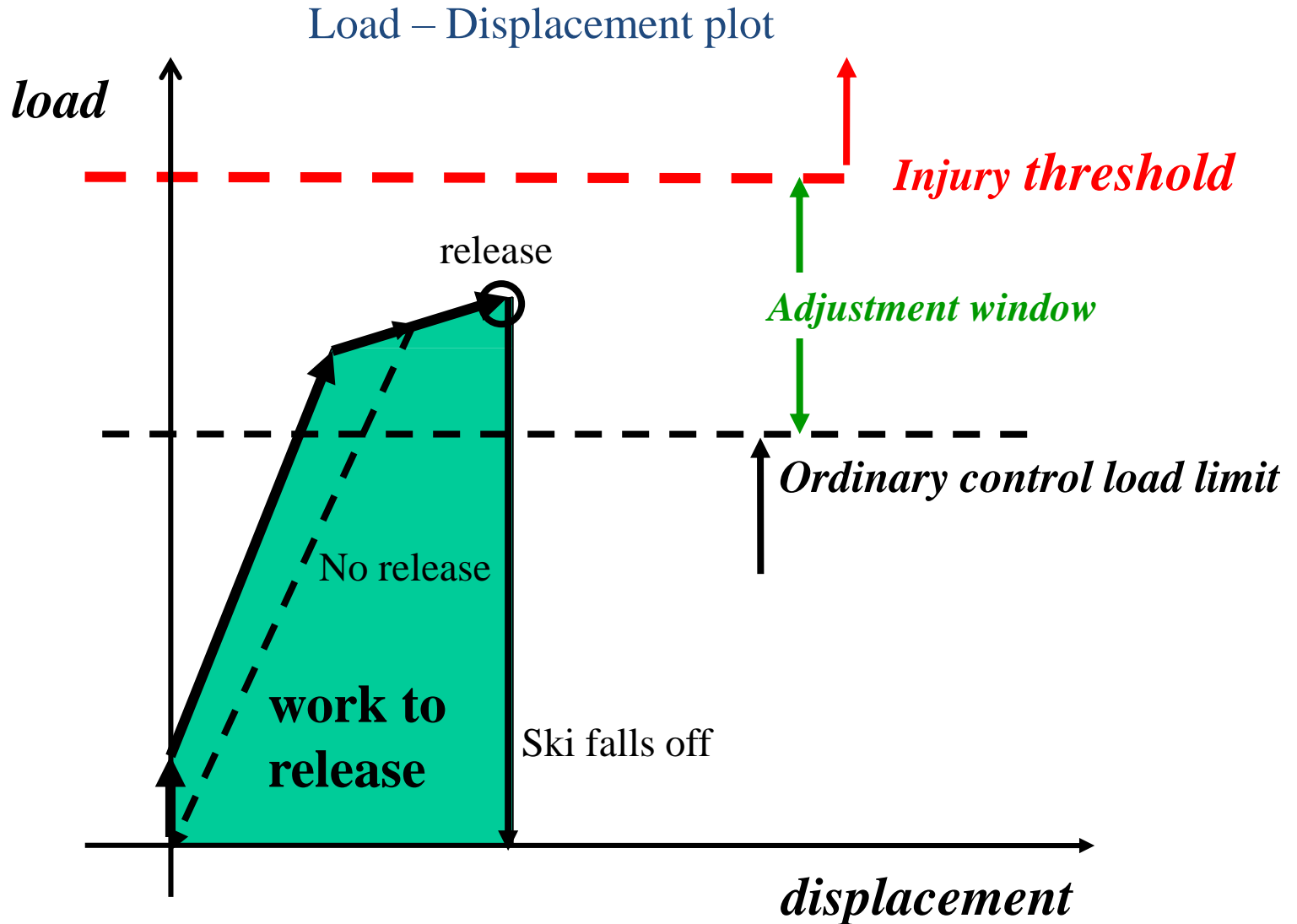
# *Don't Compromise Performance*

## **Bindings transmit loads**

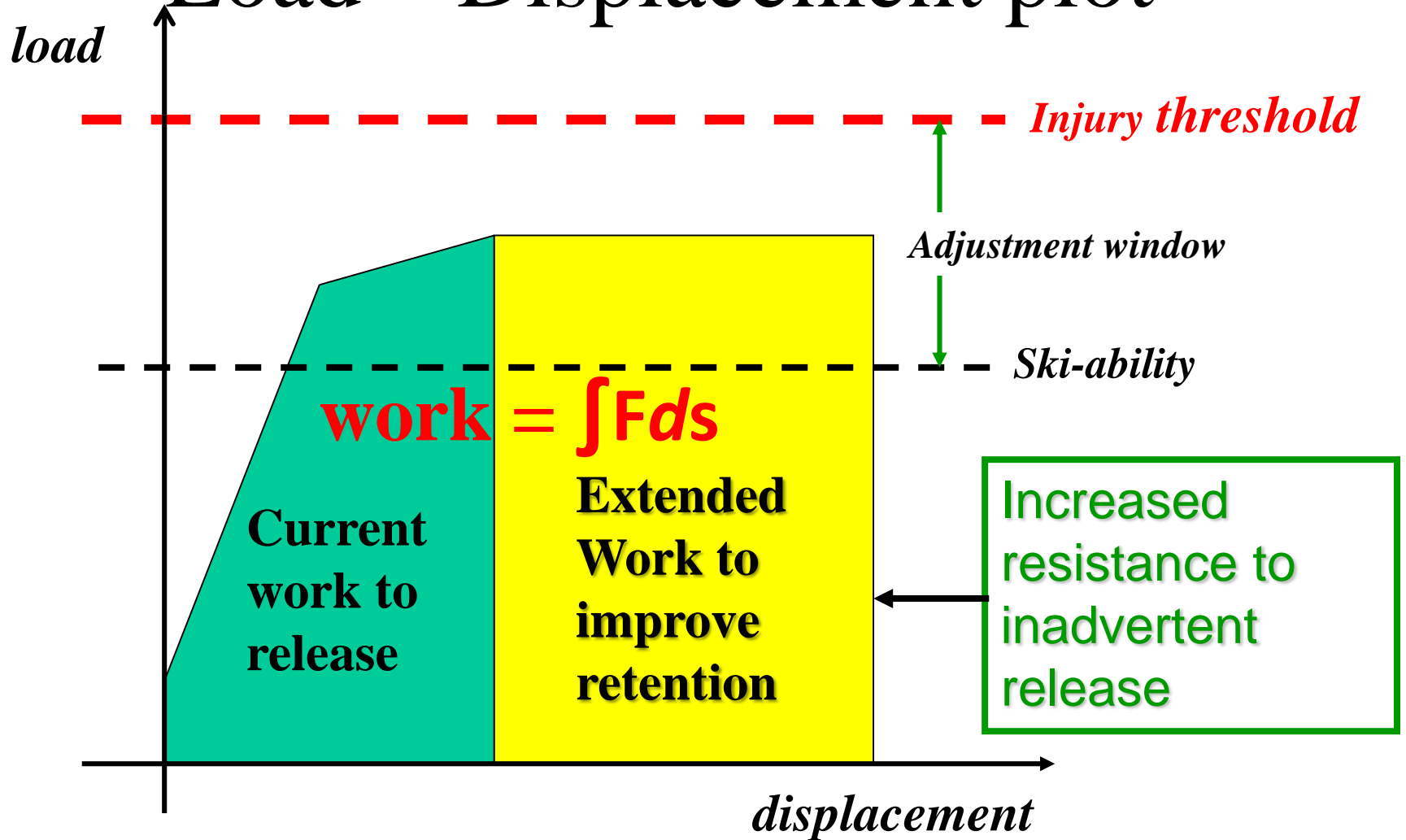
- Control loads are mostly normal to the ski
- Control loads cannot exceed injury loads
  - Injury causes loss of control
- Bindings do not have to release to protect against injury
  - *Shock absorber*
  - *Protect and retain control*



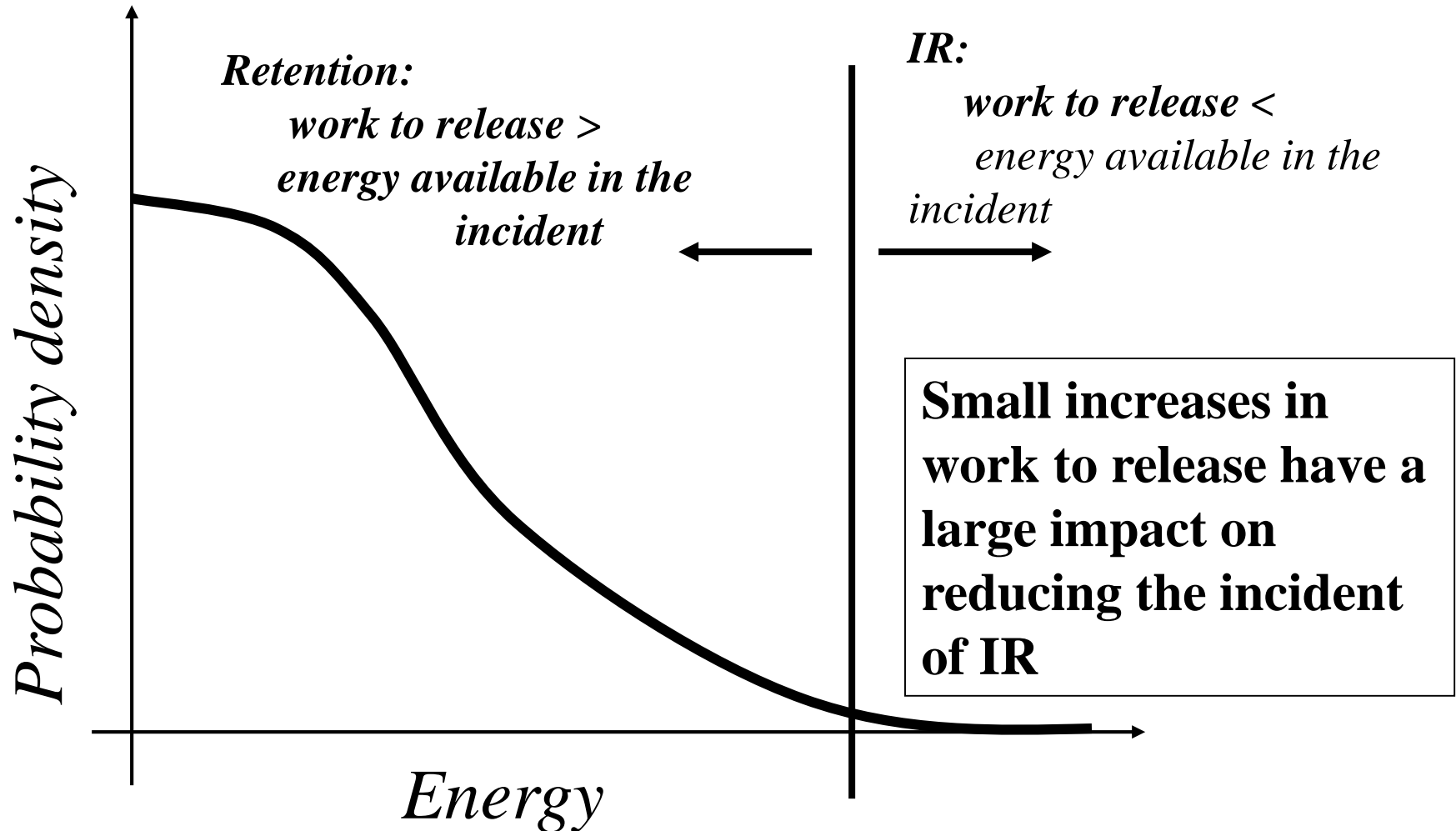
# Understanding the basic mechanics



# Load – Displacement plot

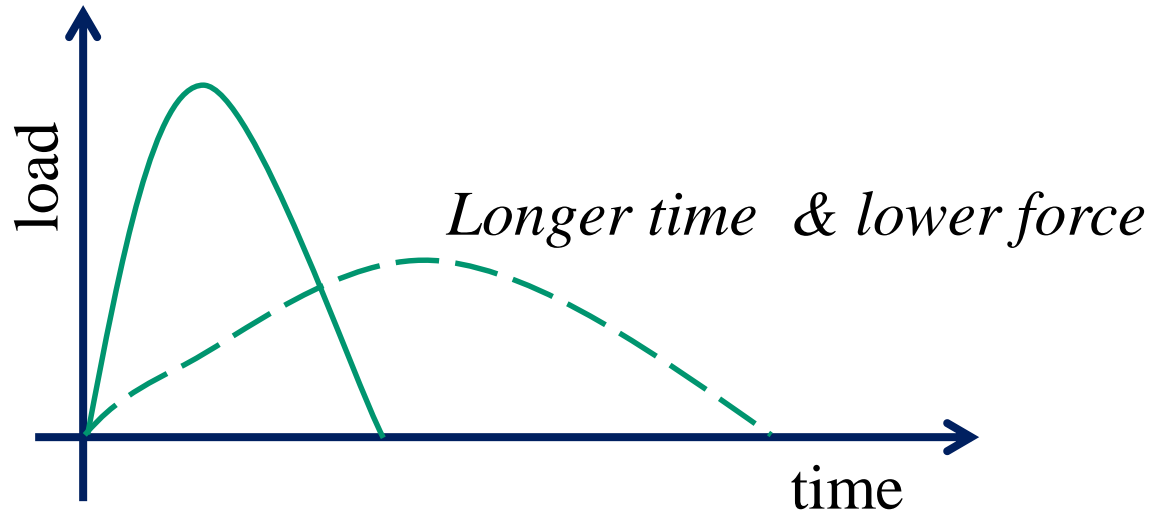


# Distribution of energies available in an incident to do work on a binding



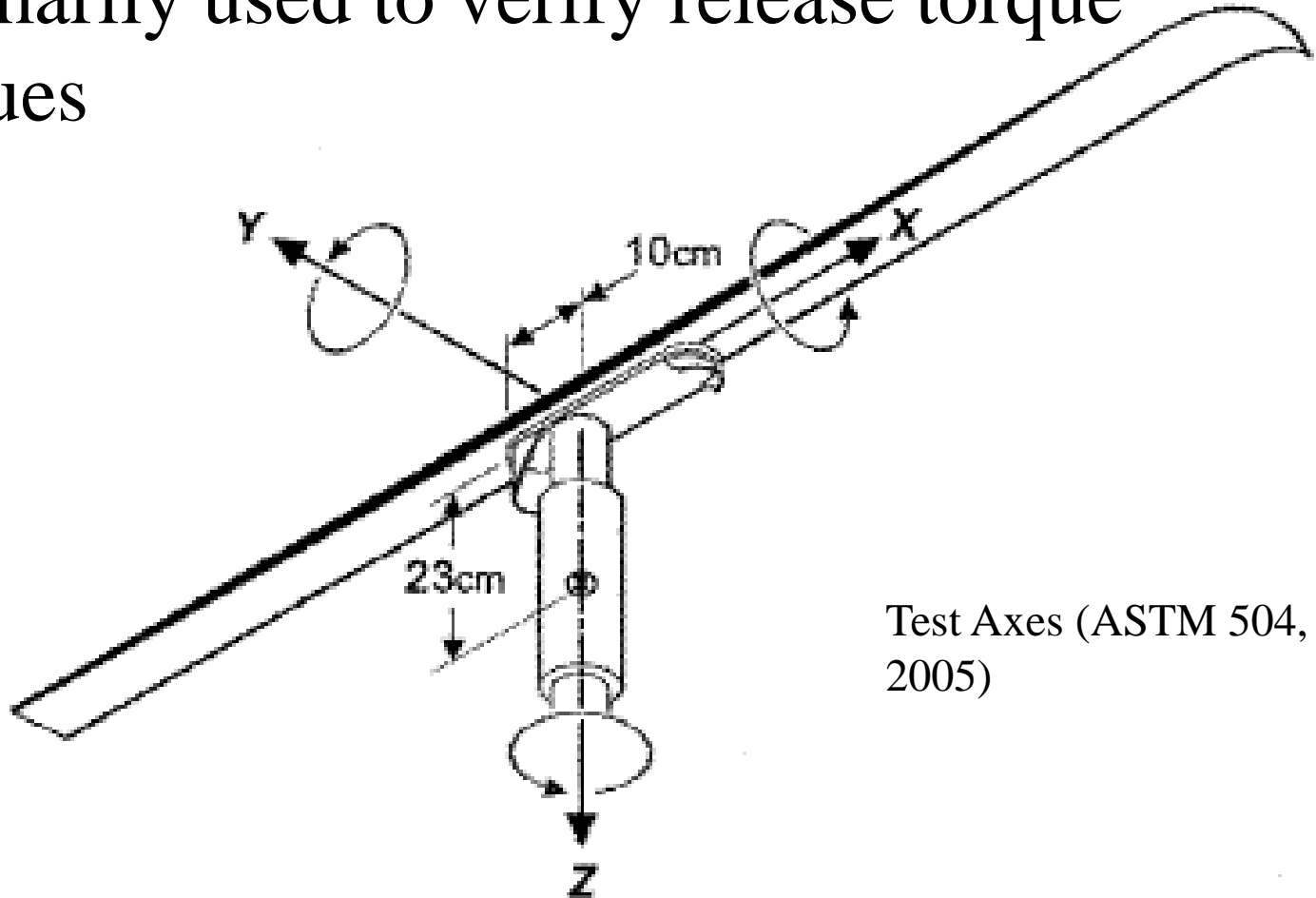
# Limited energy available to do work on the binding

- Transient nature of loading in skiing
- Impulse momentum formulation
- Impulse =  $\int F dt$



# State of the Art

- Current testing standards and devices are primarily used to verify release torque values



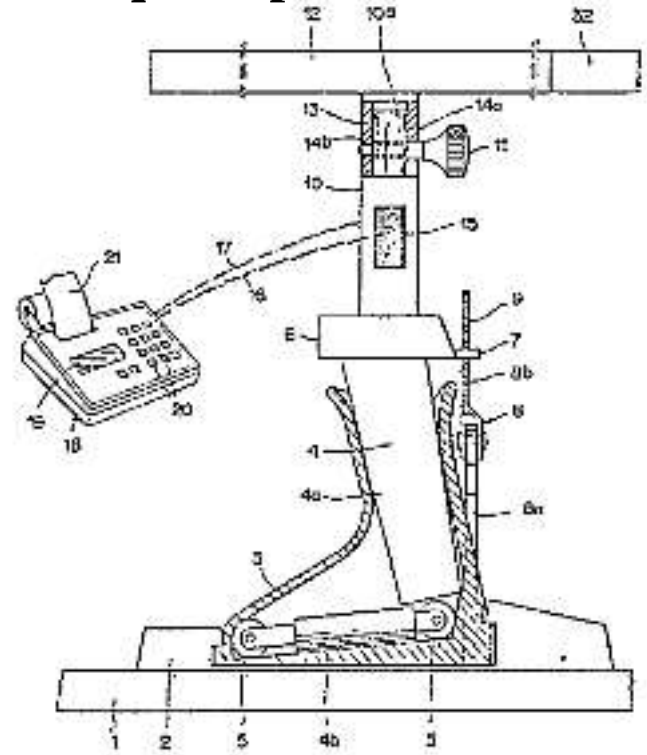
# State of the Art

State-of the art has focused on **load to release**



<http://www.vermontskisafety.com/vssehome.php>

## Jacques Epitoux Ski Binding Tester



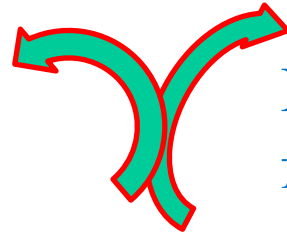
<http://www.google.com/patents/EP0305324A1?cl=en>

# State of the Art

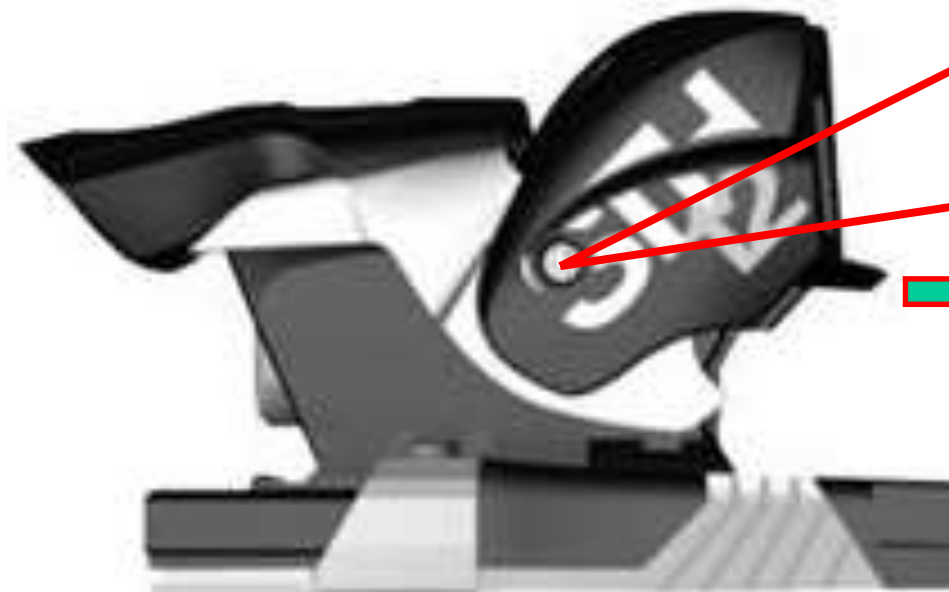
- Wintersteiger Speedtronic Pro



# heel pieces retention problems 1



Boot and binding rotate away from each other



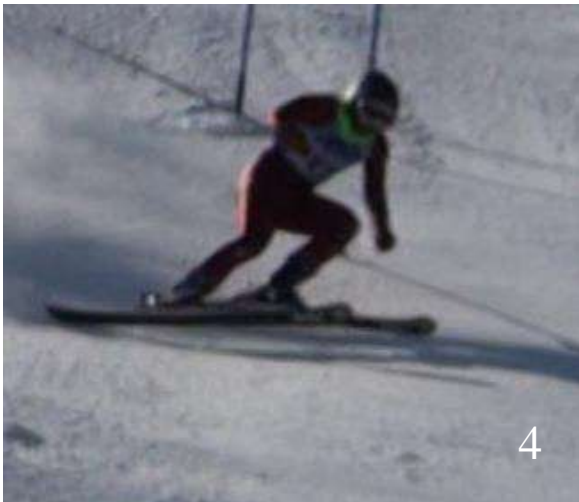
Insufficient travel before release



Binding must move forward to compensate for opposite rotation directions

# Chatter off

*Ski has a higher natural frequency than the binding*















**Ski doesn't stay on when it is flexing**

# heel pieces retention problem

## static kinematics

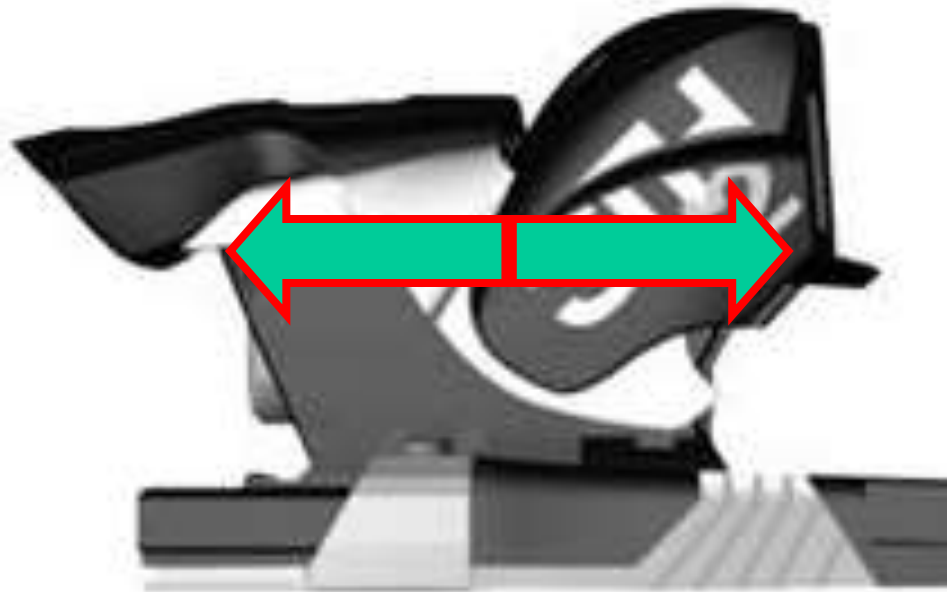


**Lower pivot  
axes tend to  
drive the heel  
open when the  
ski flexes**

# heel pieces retention dynamic response

## Conventional

Heavier heel pieces  
and weaker forward  
pressure springs  
mean  
lower natural  
frequencies and  
poorer response to  
ski dynamics



Spring and heel track  
Entire heel piece moves

# Rapid response heel piece in open position

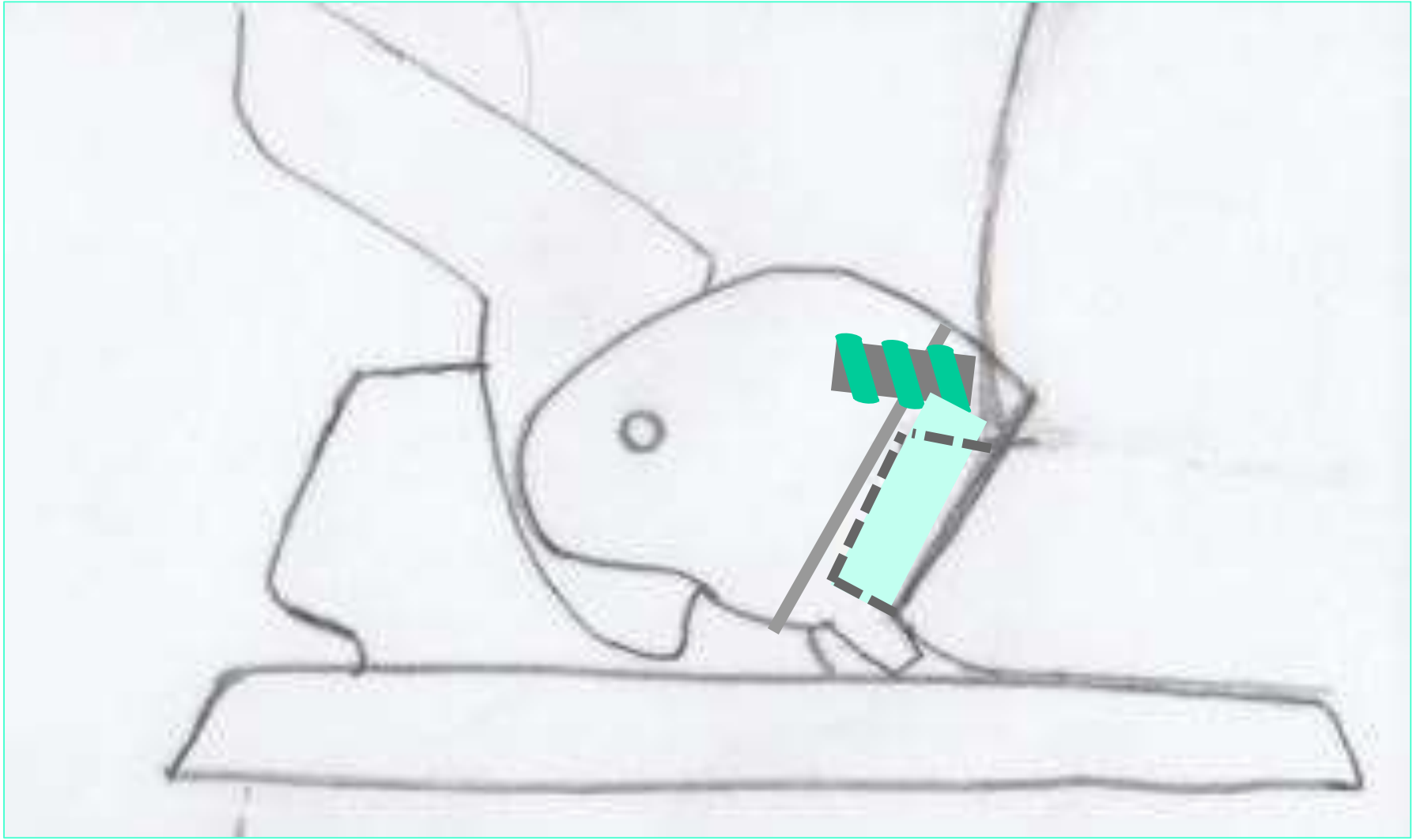


*Spring loaded heel cup*

**Lighter**  
**Stiffer**  
**Faster**

Heel track  
could be  
eliminated  
and heel  
lowered

**Patent pending**



# Solution

spring loaded extension of boot  
binding interface (toe and heel)  
might replace forward pressure track and spring

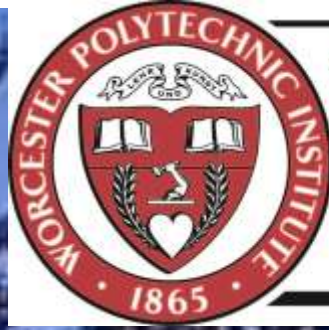


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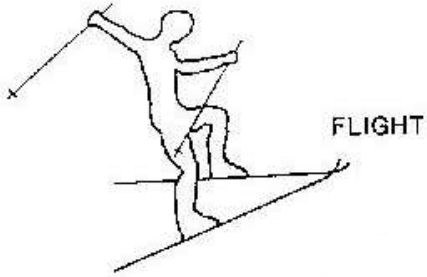
*Provisional patent – contact WPI Technology Transfer*



**WPI**

*Looking for your support!*

# ACL Injury Mechanisms



Boot Induced  
Anterior Drawer

Combined Valgus, Inward Rotation  
“Phantom Foot”  
“Slip Catch”  
“Dynamic Snowplow”



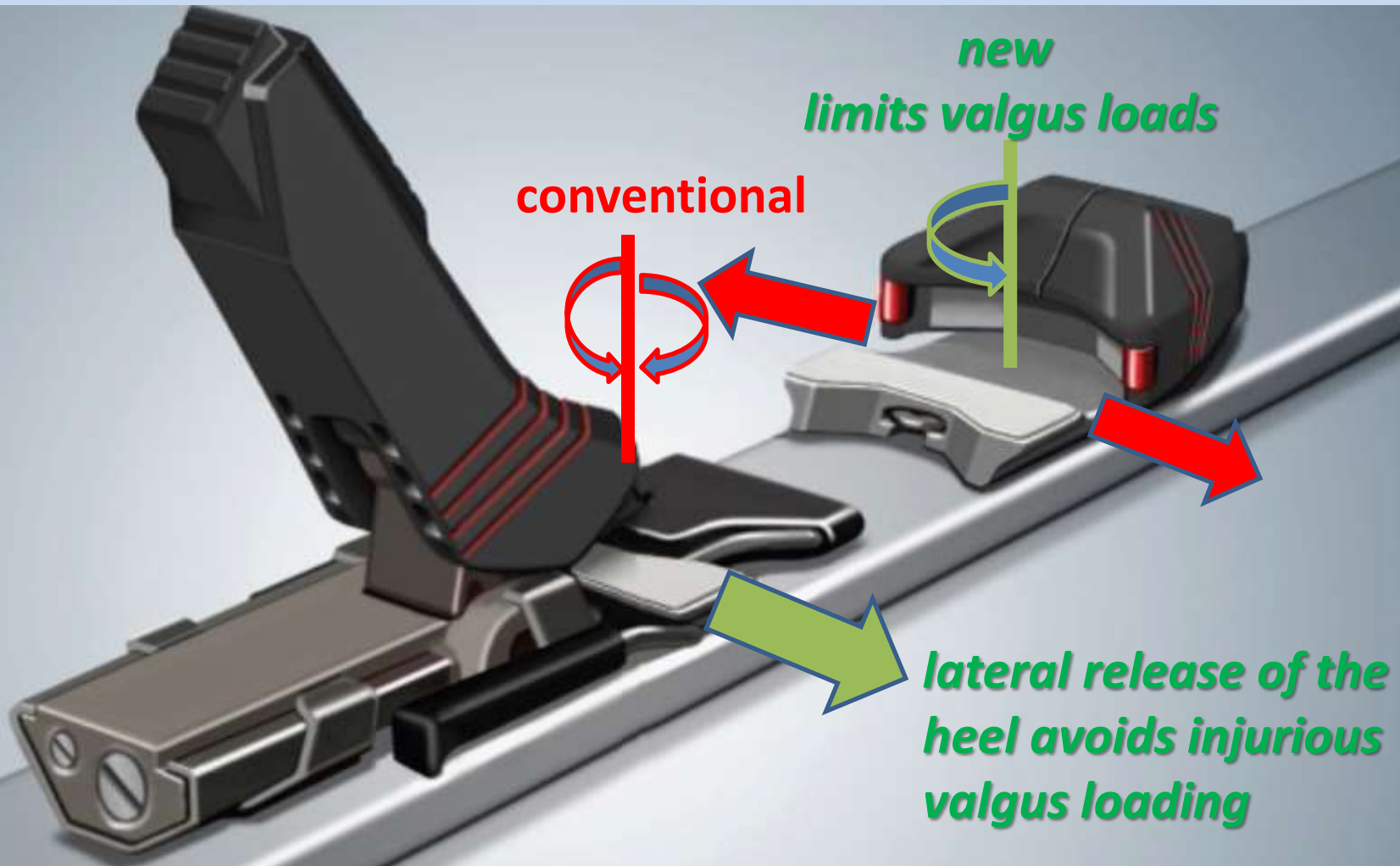
# Filter Potentially injurious valgus loads (femur torque)



Conventional bindings are insensitive  
Injurious valgus loads can result



# ACL protection – two pivots for lateral release



Also improves edging



# Also improves edging



# Conclusions

Based on engineering mechanics and design

- Bindings can reduce the risk of ACL injury
- IR can be reduced
- Need to Measure
  - Work to release
  - Valgus and tibia torque
    - both sides of the knee



Thank you for your kind attention

