Effectiveness measurement of the ski gear for the protection of the knee joint : KNEEMAX® during a volontary releasing of the toe binding

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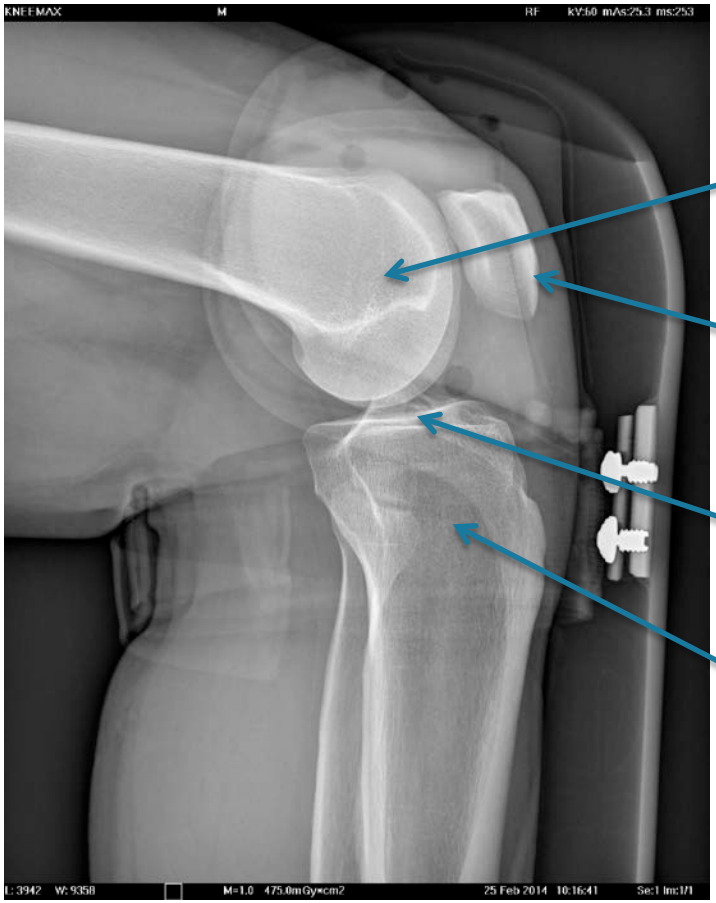
Link between the thigh bone and the KNEEMAX®

Link of the thigh bone

2 KNEEMAX ® prototypes had been provided to the French Federation of Ski and they made some radiographies of a skier equipped with the protection.



The thigh bone is held in a vice between the two molded bags

The patella is not held

Molded bags stops at the limit of the tibial tray

The flexible strap surround the leg

Restrained rotation

Free rotation

Courtesy of Nicolas Coulmy, FFS research department.

Link of the thigh bone

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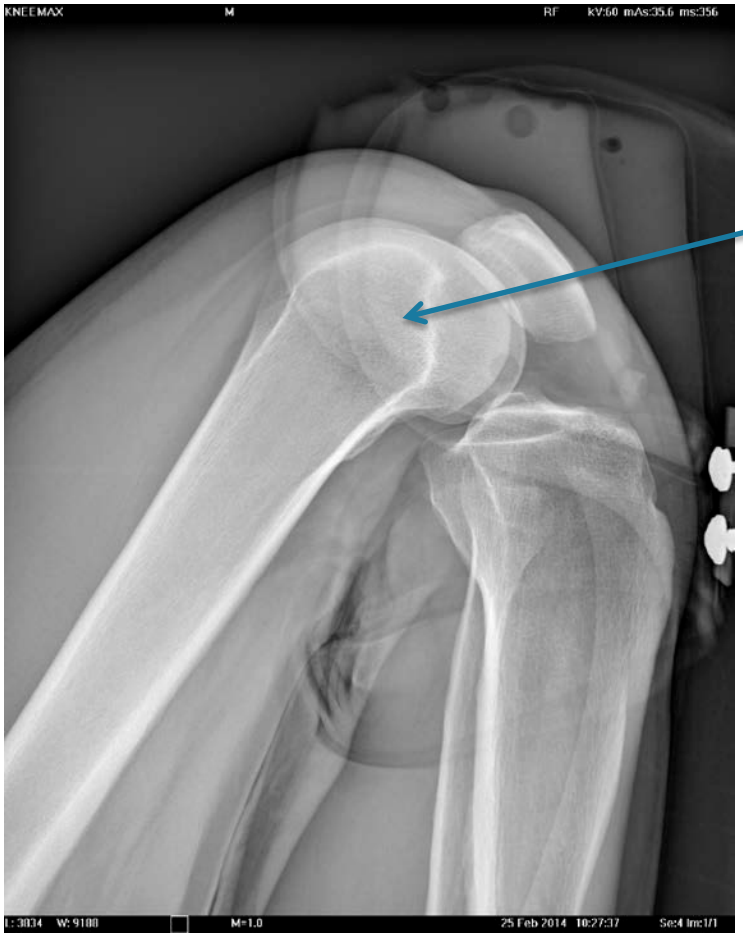
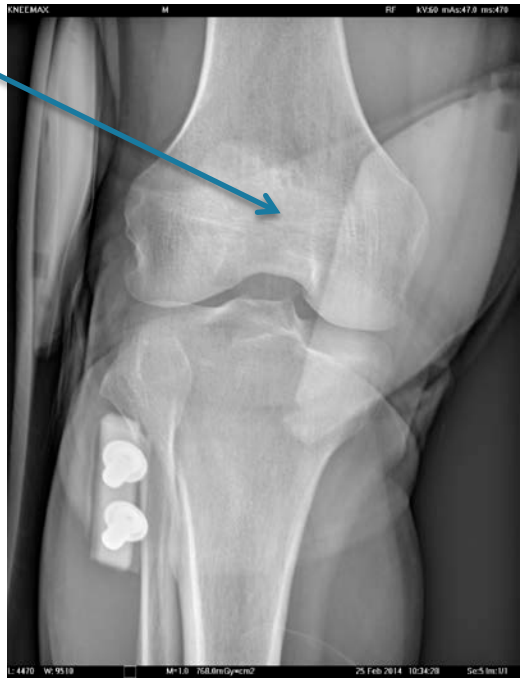


the thigh bone is held between two molded part and not fully constrained,
thus it can't cause issue for the flexion



no possibility of anterior drawer due to the protection

Courtesy of Nicolas Coulmy, FFS research department.

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Torque transmission through the KNEEMAX® for the releasing of a ski binding

Torque transmitted by the KNEEMAX®

Trial protocol

- **Ski binding FISCHER RC4 Z 13 - FREEFLEX DIN: 4-13 set to 12**
- **Ski boot FISCHER SOMA RC4 - 140-98, size 27.5**
- **The volunteer wears a KNEEMAX® carbon epoxy composite shell 5mm thickness on the right leg**
- **The knee is then molded, in-situ, with a injection pressure of a few millibars. After a curing time of between 2 and 8 minutes, the knee of the volunteer is molded in 2 parts with a up to 30 shore A material.**
- **The volunteer tries to release the ski binding with the help of the KNEEMAX®**

Curing step of molding

Torque transmitted by the KNEEMAX®

Trial protocol

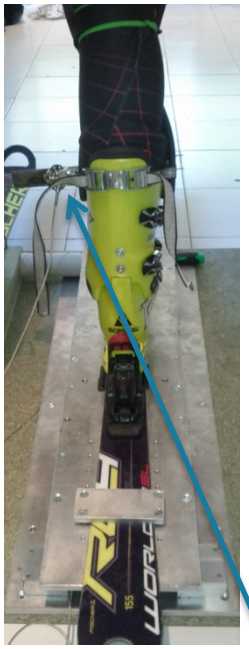
- The ski is fixed on a test bench mounted on a ball bearing and equipped with a force sensor
- The flexible strap stretched between the ski boot and the KNEEMAX® shell is equipped with the same force sensor
- The force sensor is a miniature in-line load cell working in traction and compression up to 4448N The force sensor is a FUTEK LCM300 1000lb with a USB215, scanning speed 300Hz and the Sensit software.

Torque transmitted by the KNEEMAX®

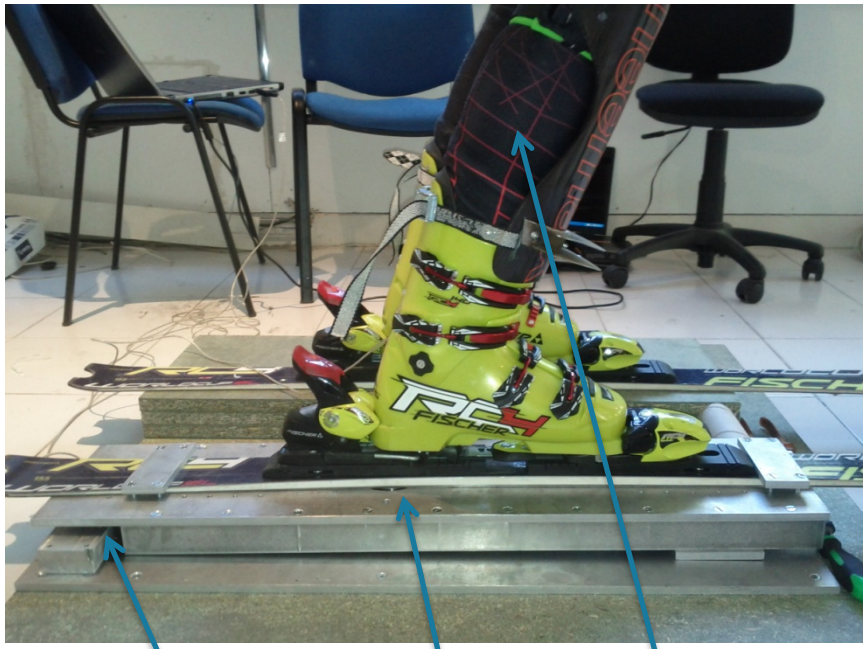
Details of the test bench

Front view

Rear view



Side view



KNEEMAX®

Ski force sensor

Volunteer

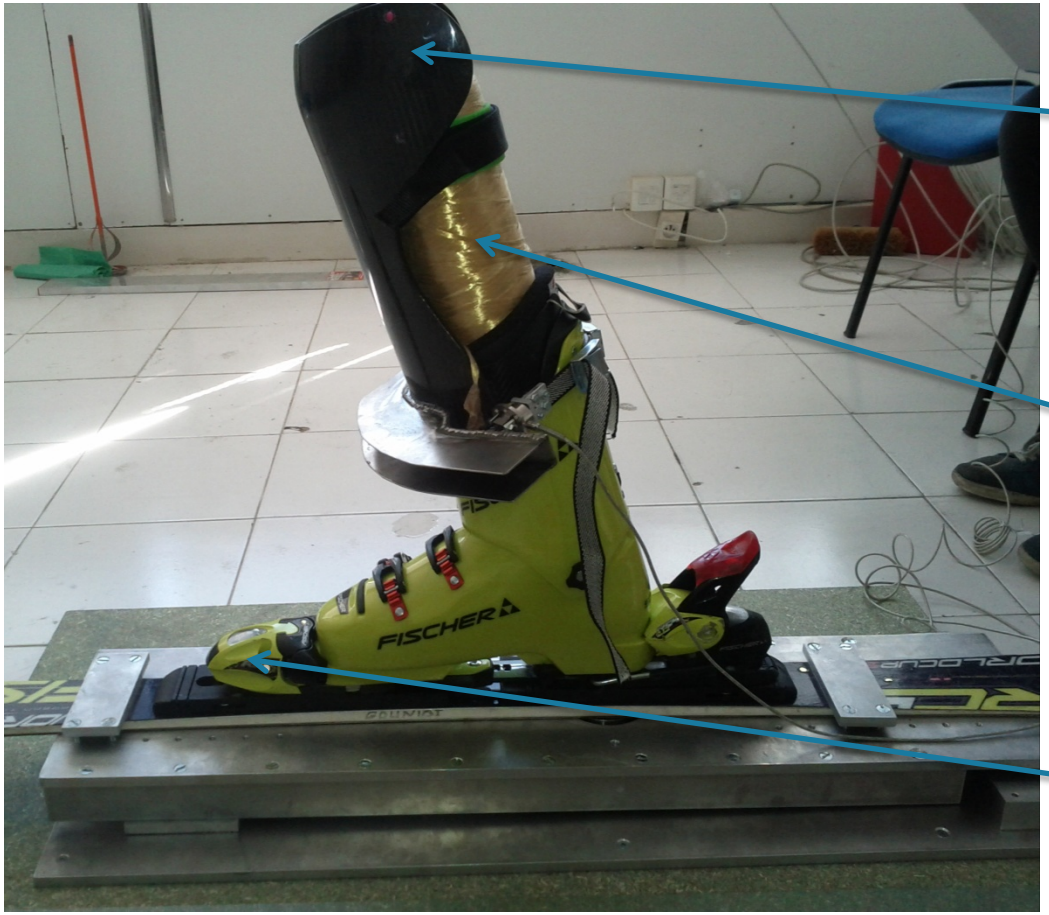
Ski binding set to 12

Strap force sensor

Ball bearing

Torque transmitted by the KNEEMAX®

First experimentation : releasing without volunteer



applying a manual force on the composite shell

Replacement of the lower limb by a cylindrical part

Setting the ski binding :
- 2 times to 4
- 2 times to 8
- 2 times to 12

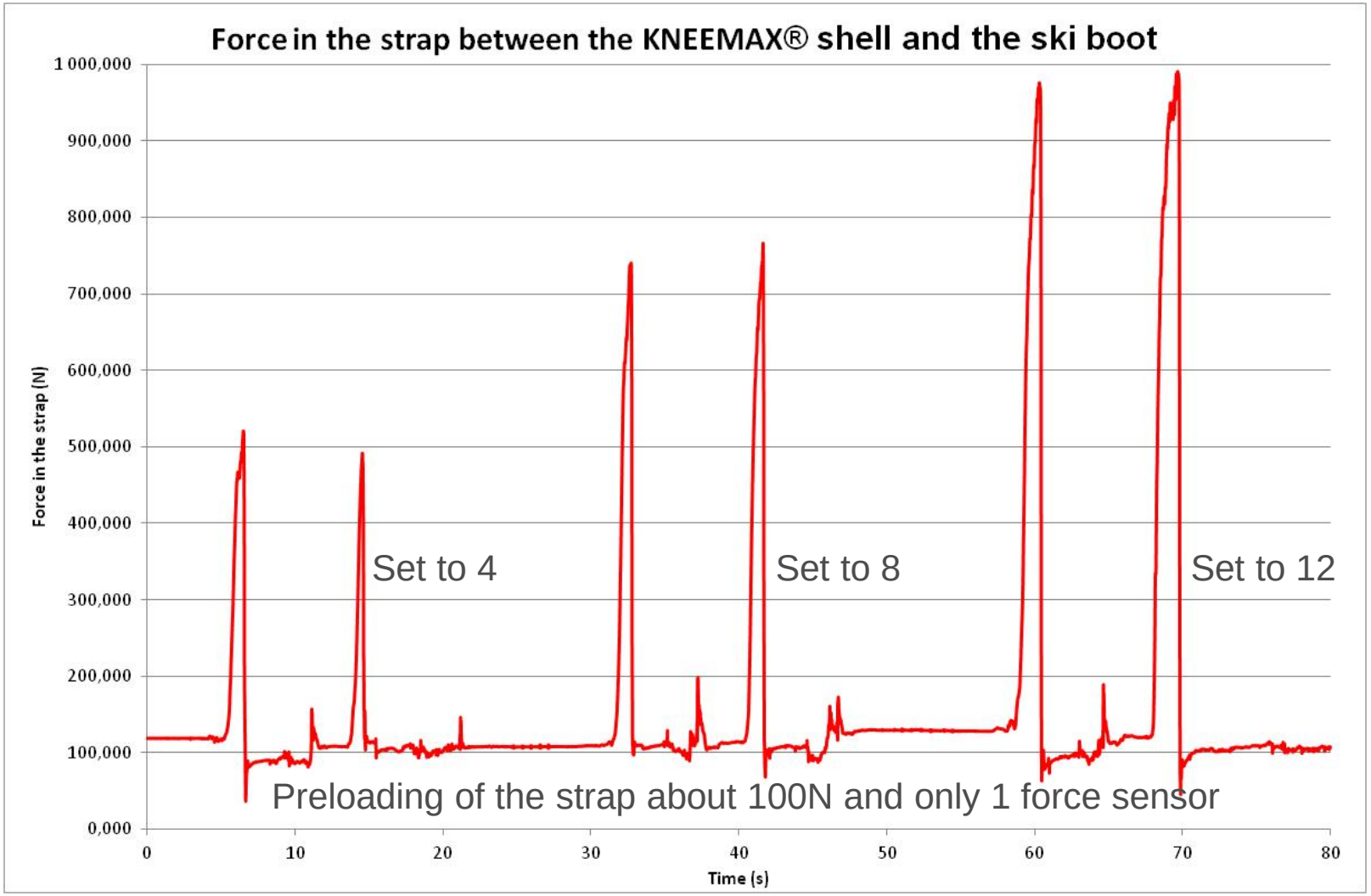
Torque transmitted by the KNEEMAX®

First experimentation : releasing without volunteer

2 times accelerated

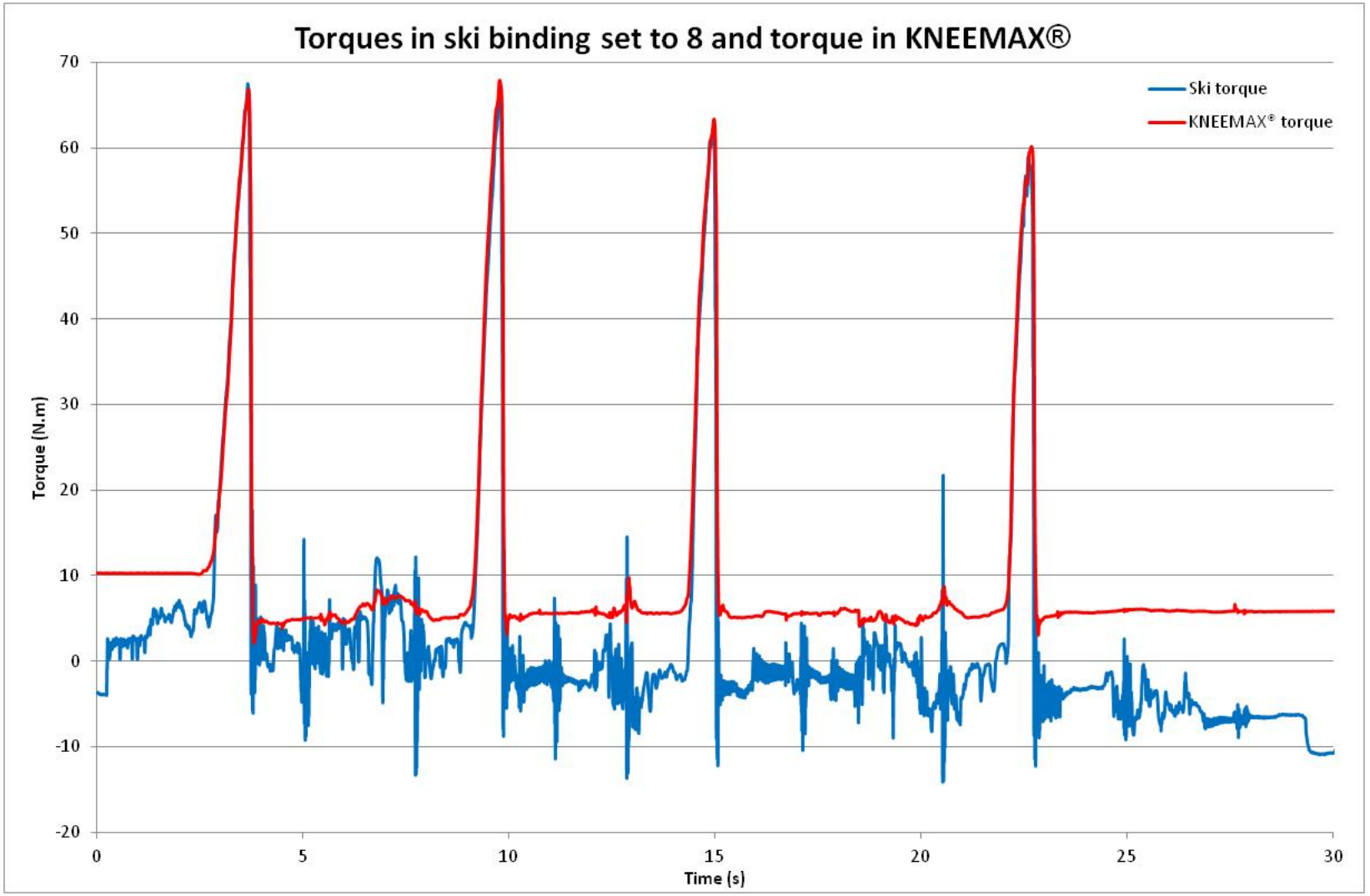
Torque transmitted by the KNEEMAX®

First experimentation : releasing without volunteer



Torque transmitted by the KNEEMAX®

First experimentation : releasing without volunteer



The 2 curves are similar during the releasing of the ski binding

Torque transmitted by the KNEEMAX®

First conclusion

- **The KNEEMAX® is able to transmit 100% of the rotational force required to release the ski binding set up to 12**
- **Reaction time is close to zero**

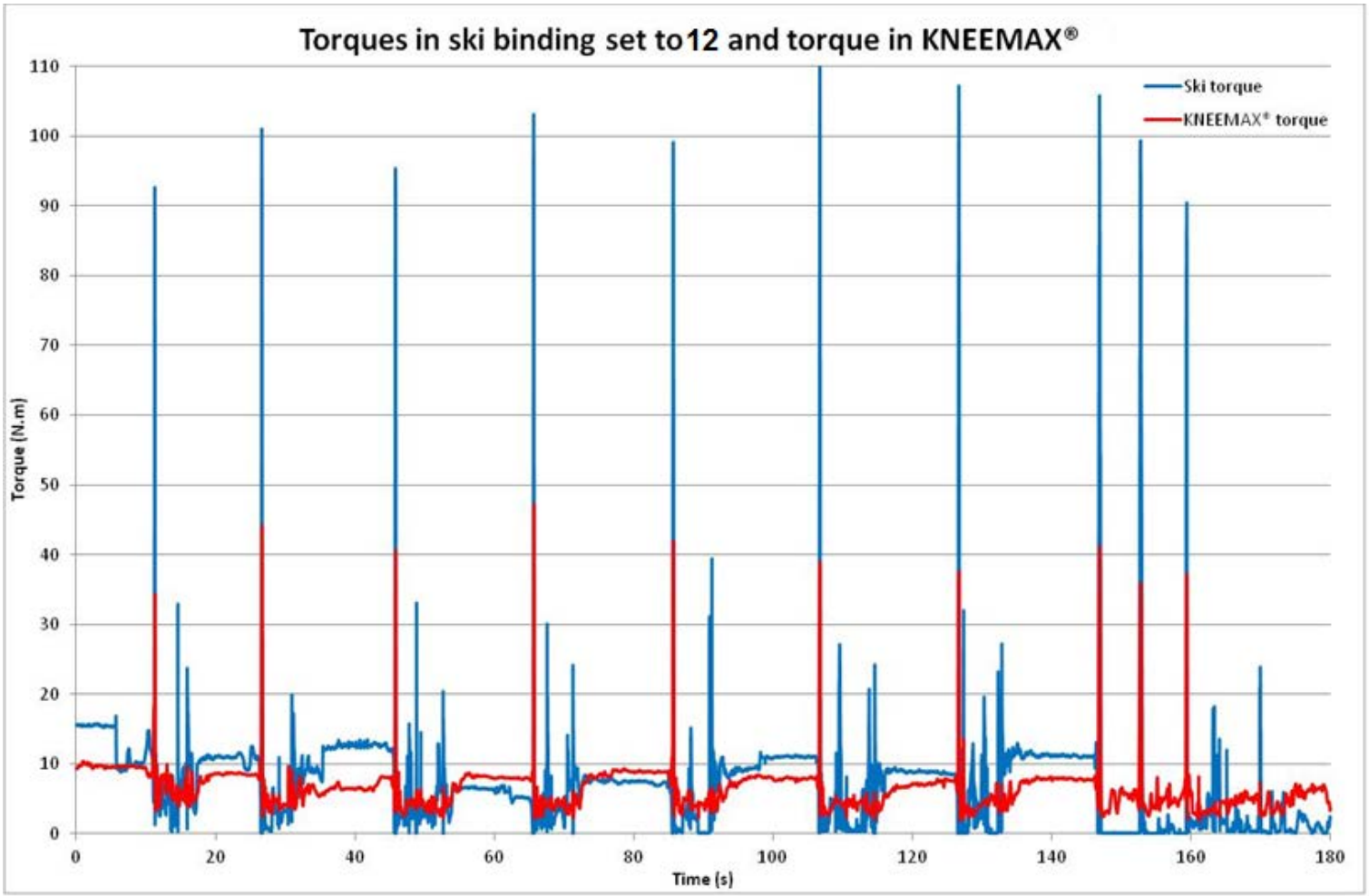
- **If the KNEEMAX ® is able to transmit 100% of the effort when there is no leg in the ski boot, what's the proportion when the volunteer releases the ski binding ?**

Torque transmitted by the KNEEMAX®

Second experimentation : a volunteer releases 8 times in a raw a ski binding set to 12

Torque transmitted by the KNEEMAX®

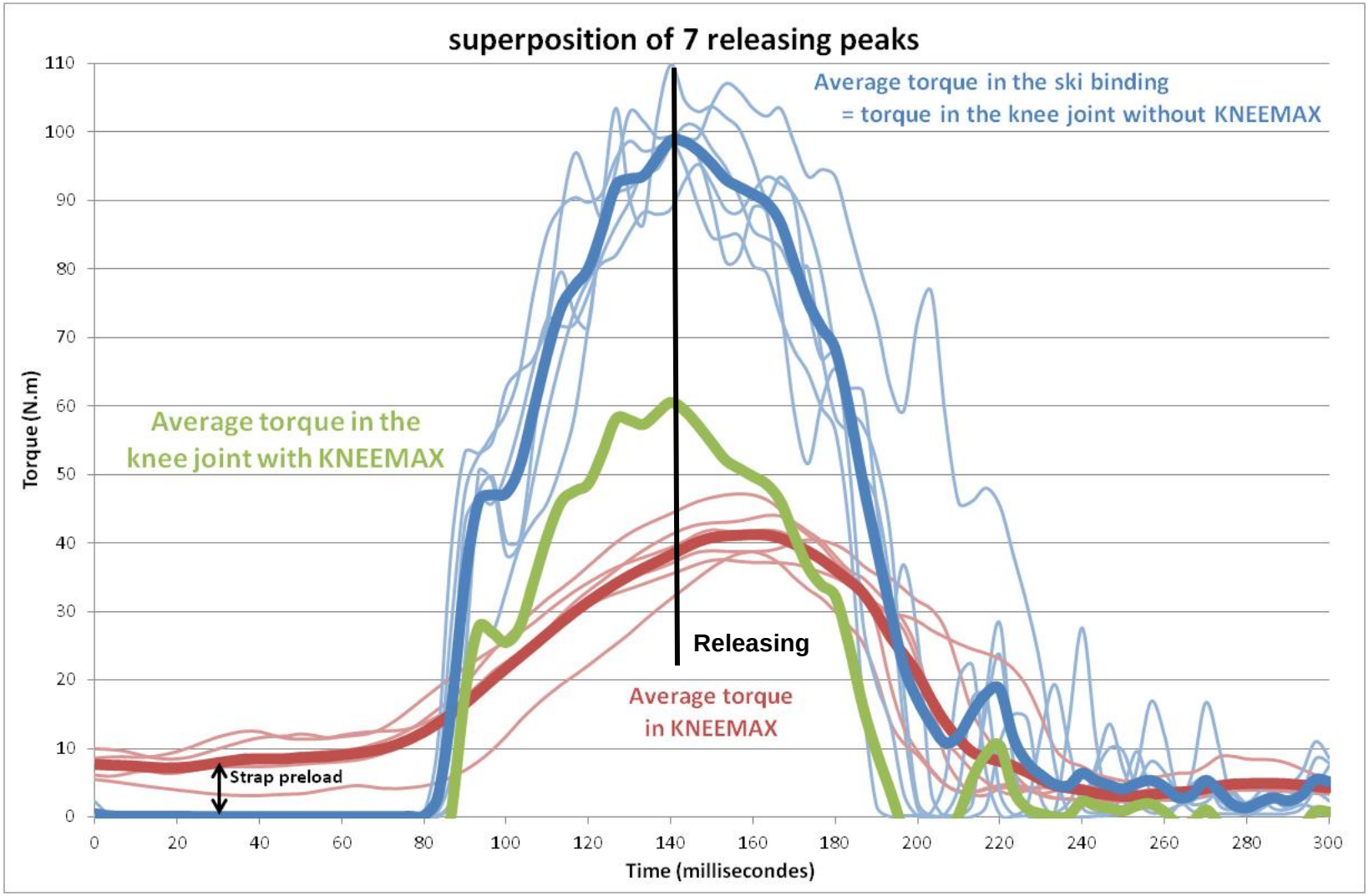
Second experimentation : a volunteer releases 8 times in a raw a ski binding set to 12



The average torques are about 40N.m in KNEEMAX®

Torque transmitted by the KNEEMAX®

Second experimentation : a volunteer releases 8 times in a raw a ski binding set to 12



The average torques are about 100 N.m in ski and 40 N.m in KNEEMAX®

Torque transmitted by the KNEEMAX®

Final conclusion

- **The KNEEMAX® is able to transmit 100% of the torque required to release the ski binding**
- **The KNEEMAX® (thus the thigh bone and the hip) transmits 40% of the torque required to release the ski binding with a contracting muscle volunteer**
- **Then the knee transmits only 60% of the torque**
- **The releasing time is about 60 ms but the KNEEMAX ® works :**
  - about 20 to 40 ms before the ski binding see anything
    => high protection since the start of the stress !
    => Can it reduce the wear of ligaments ? Can it increase the ski precision ?
  - about 20 to 40 ms after the releasing of the ski binding
    => damped shock protection on the knee

Future perspective

- **The KNEEMAX® is able to protect skiers from knee's injuries and also leg's injuries**
- **The KNEEMAX® can probably prevents the wear of knee's ligaments**
- **The KNEEMAX® blocks the knee rotation until the releasing of the ski binding**
- **The KNEEMAX® doesn't cause issues for skiing**
- **The KNEEMAX® can probably increase performances in slalom**

- **It is necessary to perform more tests with different configurations (volunteers, skis bindings, postures, etc.) on the test bench equipped with a second force sensor on the KNEEMAX® to study the torque under the strap preload**
- **Should perform tests on released muscle => cadaver**

thank you for your attention