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Sled Tests with Footwell Intrusion - First Experiences

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ABSTRACT

It will be reported about a footwell intrusion device installed on the sled for frontal collisions. The footwell intrusion is simultaneously translational (70 mm) and rotational (30 degrees). The intrusion device is mechanically activated about 50 ms after t_0. Furthermore a dashboard simulation is installed on the sled. The subject is belted with a 3-point standard belt and is sitting on a rigid seat. First results with 50 km/h frontal collisions by using H-III-Dummies and one post mortem human surrogate will be reported.

INTRODUCTION

The structural deformation of the occupant compartment, frequently referred to as intrusion, greatly increases the severity of the impact response and the risk of injury for the occupant. Lower extremity injuries of front seat car occupants have the priority for prevention because of their potential for causing long term impairment and disability. To determine the incidence and mechanisms of lower extremity injuries in frontal collisions studies with controlled test parameters and conditions are needed. Sled tests with simulation of structural intrusion of the footwell are suitable to investigate this issue. At the University of Heidelberg a footwell intrusion device was installed on the sled. The first test with a post mortem human surrogate is reported on in the following. As a part of the EC Project ADRIA (Advanced crash Dummy Research for Injury Assessment in frontal test conditions) the University of Heidelberg had planned to perform sled tests with dynamic footwell intrusion by using postmortem human surrogates. The intrusion device was equipped and constructed as a diploma thesis by BMW, Munich.

METHOD

A side view of the device is illustrated in figure 1, an oblique view is illustrated in figure 2.

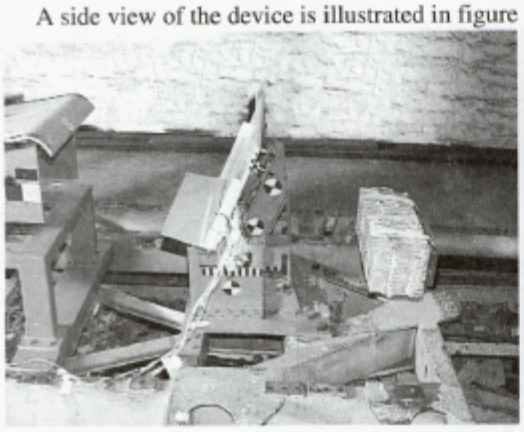


Figure 1: Side view of the intrusion device with the impactor

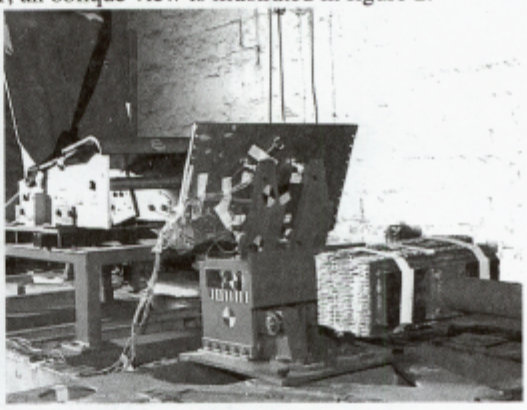


Figure 2: Oblique view of the intrusion device with the impactor

The intrusion device is installed on the sled and is activated mechanically about 50 ms after t_0. The activation is initiated by an impactor whose impact surface is bolstered by an aluminum honeycomb structure. The impactor was fixed on the rails. The footplate is 50 cm wide and 29 cm high. The footwell intrusion involves both feet and is simultaneously translational (135mm) and rotational (30°). A horizontal platform supports the heels. Figure 3 shows the initial and the end position of the footwell intrusion. Furthermore a dashboard simulation with knee bolster is installed on the sled. For the simulation of the knee bolster a styrofoam was used with a density of 30 to 33 kg/m^3, compression 20%: 240-290 kPa, compression 40%: 350 ±50 kPa.

The subject is belted with a three-point standard belt (8% elongation) and is sitting on a rigid seat. Figure 4 shows a side view of the sled with its construction devices.The dashboard simulation is rigid, the distance to the knee bolster is adjusted by the seat in x-and z-direction.

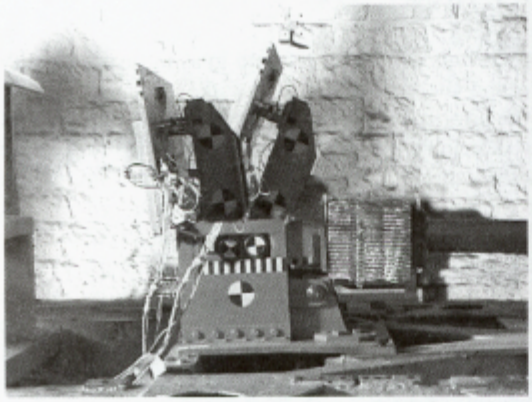


Figure 3: Initial and end position of the footwell intrusion device

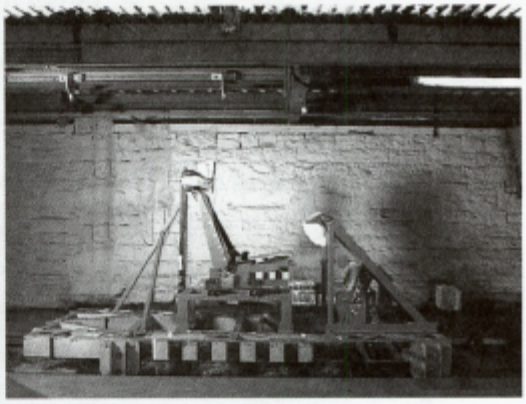


Figure 4: Side view of the sled with all construction devices

MEASUREMENTS

Sled deceleration: x-direction; Acceleration of the intrusion device: x-direction (miniature accelerometer); Footwell impact forces: x-direction (load cells were mounted at the footloading area of the footplate, see figure 5); Footwell plate: acceleration in x- & z-direction at the upper and lower part of the plate (miniature accelerometrs mounted at the rear of the plate, see figure 5)

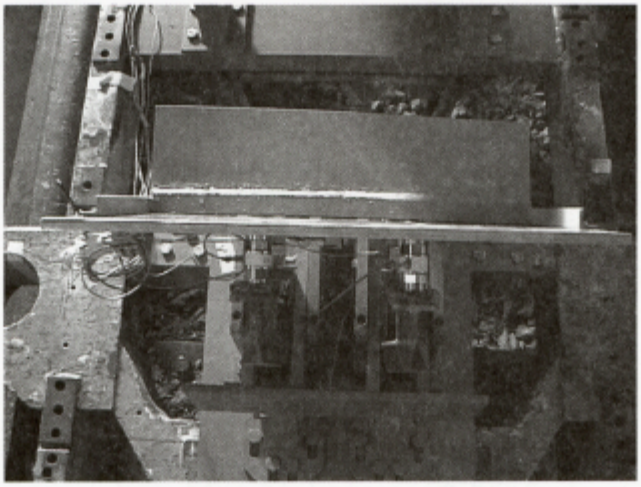


Figure 5: Top view of the footwell intrusion device with the force and acceleration transducers

DUMMY TESTS

In order to test the function of the footwell intrusion device frontal collisions with belt-protected Hybrid-III-Dummies were performed. The impact velocity was 50 km/h.
The Hybrid-III-Dummy was equipped with instrumented legs.

Figure 6 shows a side view of the belt protected Hybrid-III-Dummy. Figure 7 shows an oblique view of the same test before the run.

Figure 6: Side view of the belt protected Hybrid III Dummy

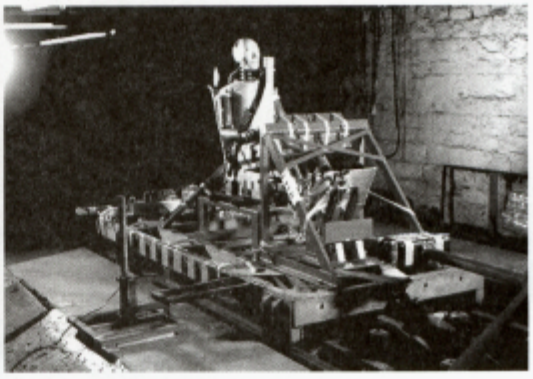


Figure 7: Oblique view of the belt protected Hybrid III Dummy

Figure 8 shows the axial force-time-histories of the lower tibia left and right. The maxima of the measured forces amount to 6.88 kN for the left tibia and to 6.18 kN for the right tibia at the time of the intrusion.

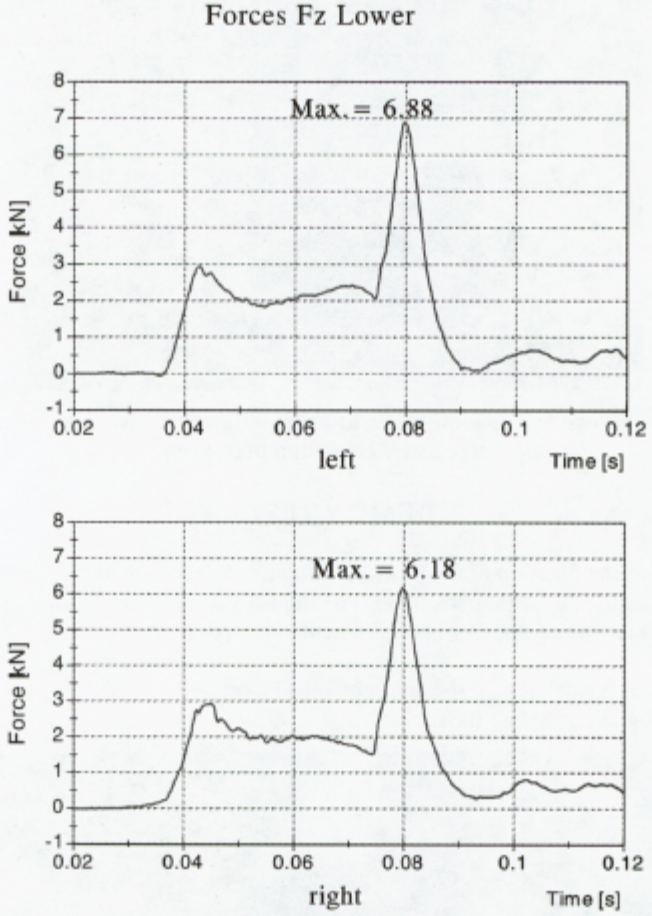


Figure 8: Axial Force-Time Histories for the lower tibia left and right

Figure 9 shows the moment about the x-axis of the lower tibia left and right. The maxima of the measured moments amount to 77.6 Nm for the left tibia and to 52.0 Nm for the right tibia at the time of the intrusion.

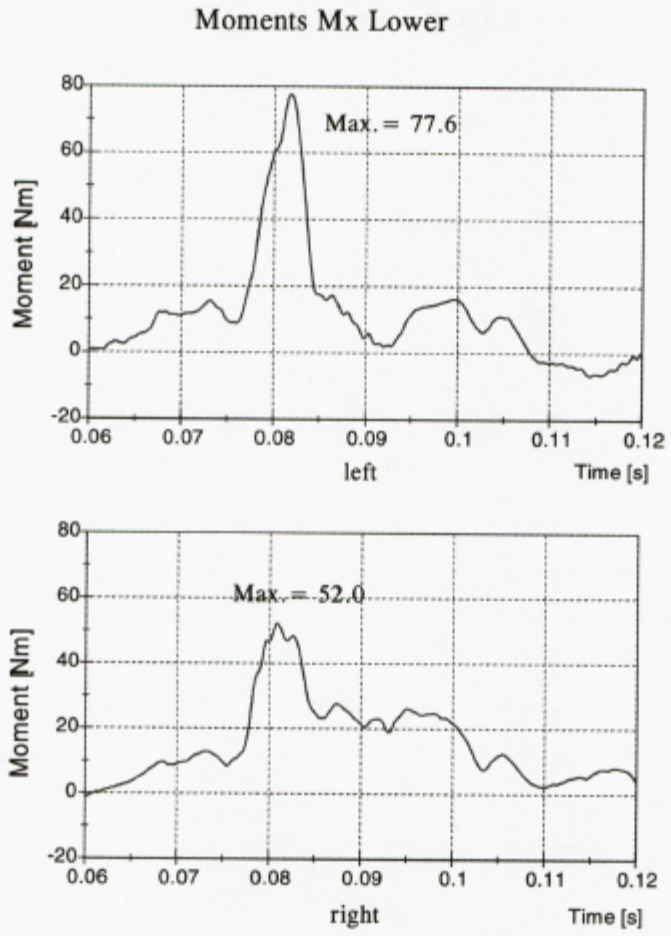


Figure 9: Moment about the x-axis of the lower tibia left and right

Figure 10 shows the femur forces of the lower tibia left and right. The maxima of the measured femur forces amount to 4.60 kN for the left tibia and to 3.74 kN for the right tibia at the time of the intrusion.

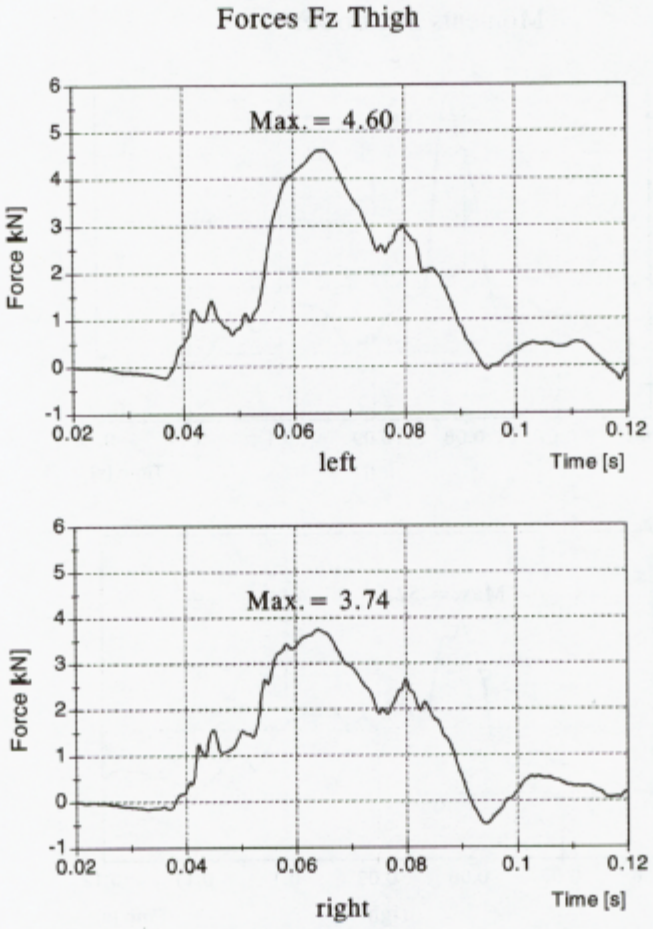


Figure 10: Femur forces of the lower tibia left and right

TEST WITH A POSTMORTEM HUMAN SURROGATE

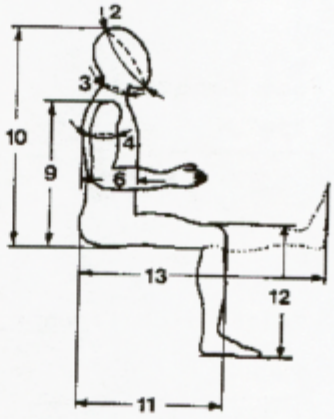
For the test a 45 years old male, body weight 80 kg, body height 169 cm was used; table 1 shows the global anthropometric data, in table 2 more detailed data of the leg are documented. A frontal impact of a 50 km/h with the sled of the Institute of Forensic Medicine of the University of Heidelberg is simulated. Figures 11 and 12 show a side and an oblique view of the belted subject. Furthermore figure 13 shows a side view of the sled devices with the belted subject and the most important dimensions.

Table 1: Anthropometric Data

Body weight 80kg

Body length..... 169 cm

1. Hat size	58	cm
2. Occip.-chin circumfer	66	cm
2a. Head height	21,8	cm
2b. Head length	19,7	cm
2c. Head breadth	16,2	cm
3. Neck circumference	43	cm
4. Upper arm circumfer	33	cm
5. Chest circumference	96	cm
6. Chest height	23	cm
7. Chest width	33,2	cm
8. Abdomen circumfer.....	97	cm
9. Buttocks - shoulder	67	cm
10. Seat height	90	cm
11. Pelvis - knee	58	cm
12. Sole of foot - knee	50	cm
13. Pelvis - heal	97	cm



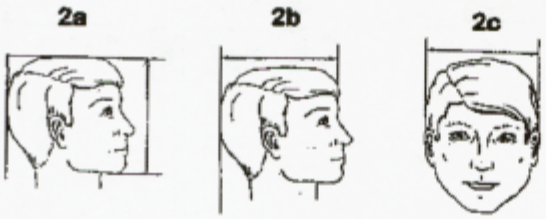


Table 2: Anthropometric Data

Foot Breadth

FOOTBD

	3	4	. 5	cm

Ankle Height

ANKLHT

		8	. 5	cm

Foot Length

FOOTLN

	2	4	. 5	cm

Knee Height, Seated

KNEEHT

	5	0	. 0	cm

Thigh Circumference

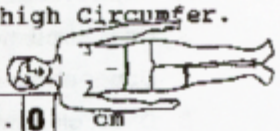
THGHCR

	5	6	. 0	cm

Lower Thigh Circumfer.

LTGHCR

	4	0	. 0	cm



Knee Circumference

KNEECR

	4	0	. 0	cm

Ankle Circumference

ANKLCR

	2	4	. 5	cm

Buttock Depth

BUTTDP

	1	6	. 3	cm

Calf Circumference

CALFCR

	3	9	. 0	cm

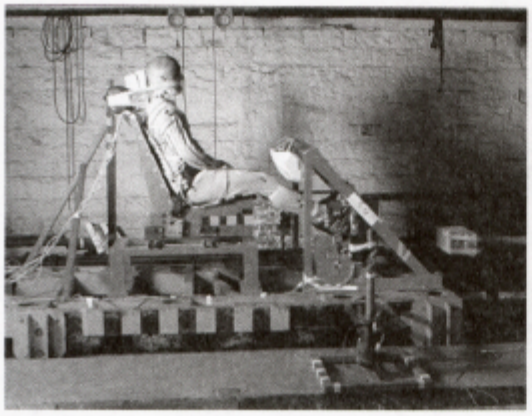


Figure 11: Side view of the belted subject

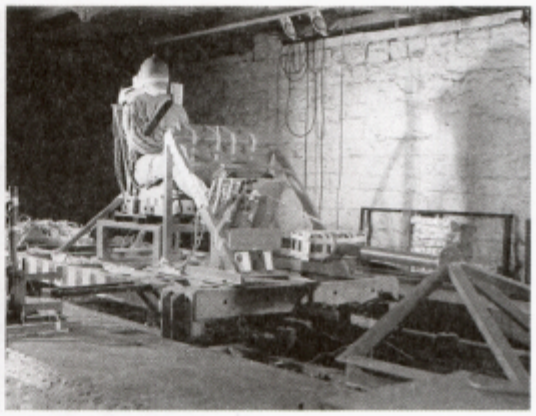


Figure 12: Oblique view of the belted subject

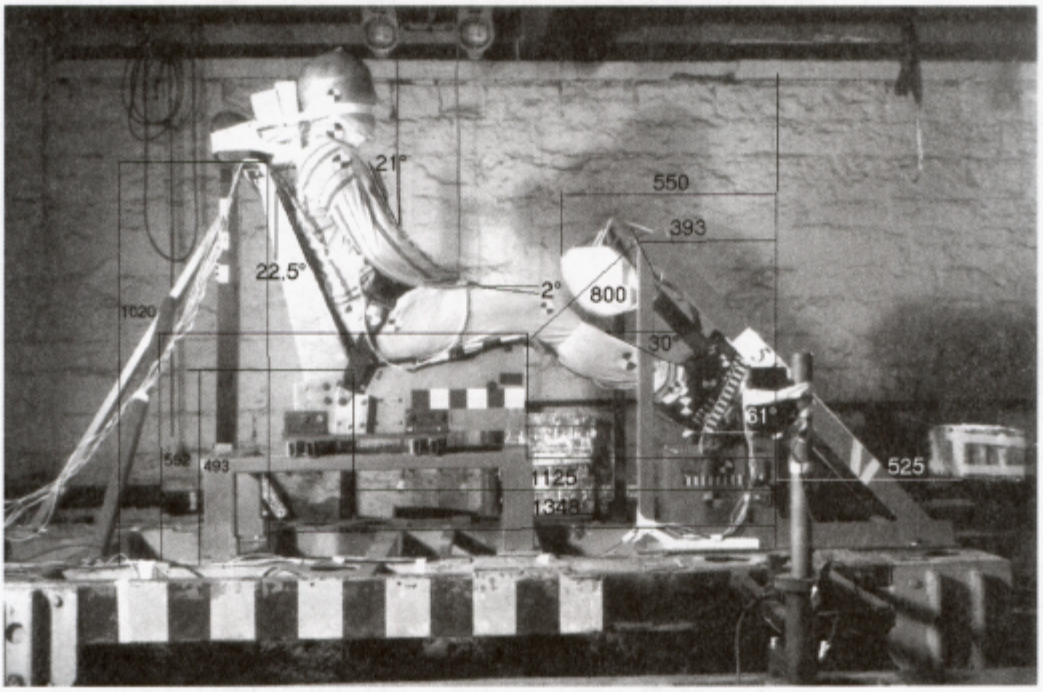


Figure 13: Side view of the sled and important dimensions

MEASUREMENTS OF THE SUBJECT

Lower tibia left and right x-,y- & z-acceleration

Semi-zylindric mounts were fixed with wires on the lower third of the tibia, a three-axial mount was fixed with screws on this semi-zylindric mount. The three-axial mount was finally completed with three uniaxial accelerometers.

PHOTOGRAPHIC DOCUMENTATION

Photographs before and after the test, high speed video (lateral, 1000 pictures/s)

MECHANICAL RESPONSE

During the activation of the intrusion device a maximum acceleration of 40g was produced.
Additional measurements:

Intrusion force: 7.4 kN
Footwell plate, upper part: max. 200g
Footwell plate, lower part: max. 120g
Resultant acceleration: lower tibia left max.: 250g
lower tibia right max.: 150 g

Figure 14 shows the deceleration-time history of the plate which activated the footwell intrusion device. The activation of the plate takes place about 50 ms after the crash. The maximum deceleration of the plate is 40 g.

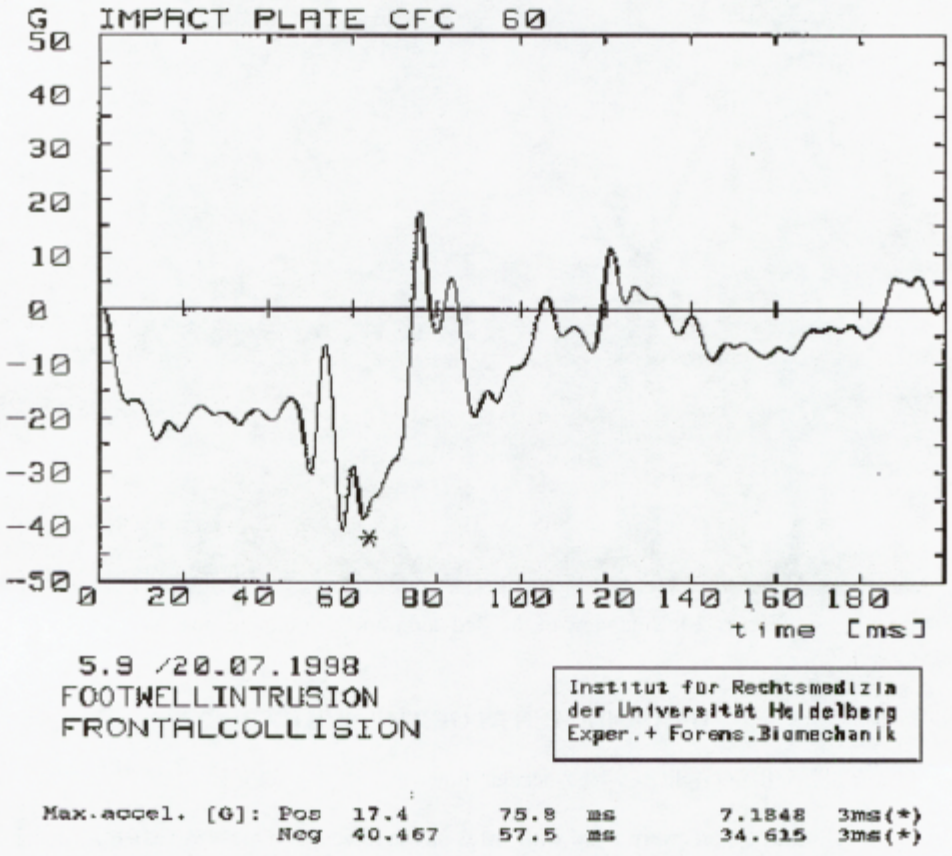


Figure 14: Deceleration-Time History of the plate

Figure 15 illustrates the force-time history of the footplate. A maximum force of 7.4 kN is observed at a time of about 60 ms after the crash.

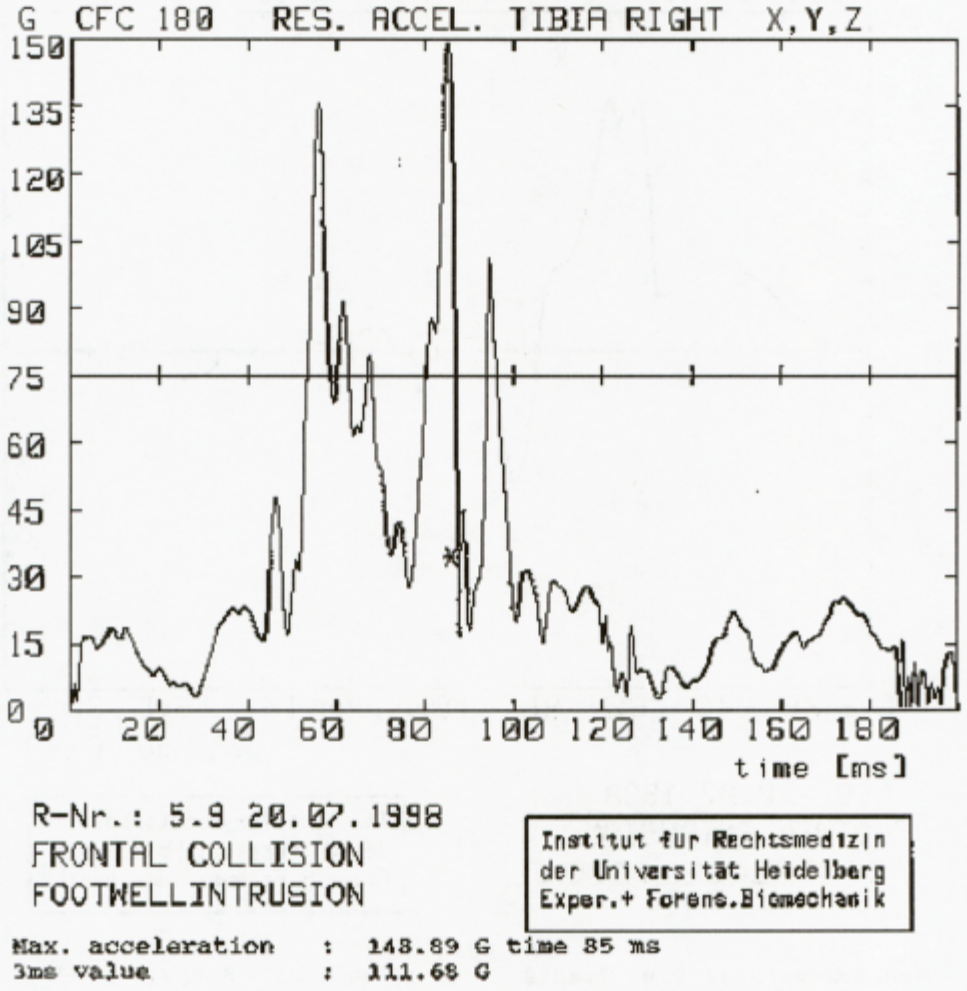


Figure 15: Force-Time History of the plate

Figure 16 illustrates the resultant acceleration at the lower tibia right over time. Two maxima are observed. The first one with 135 g at about 60 ms after the crash and the second one with 149 g at about 90 ms after the crash.

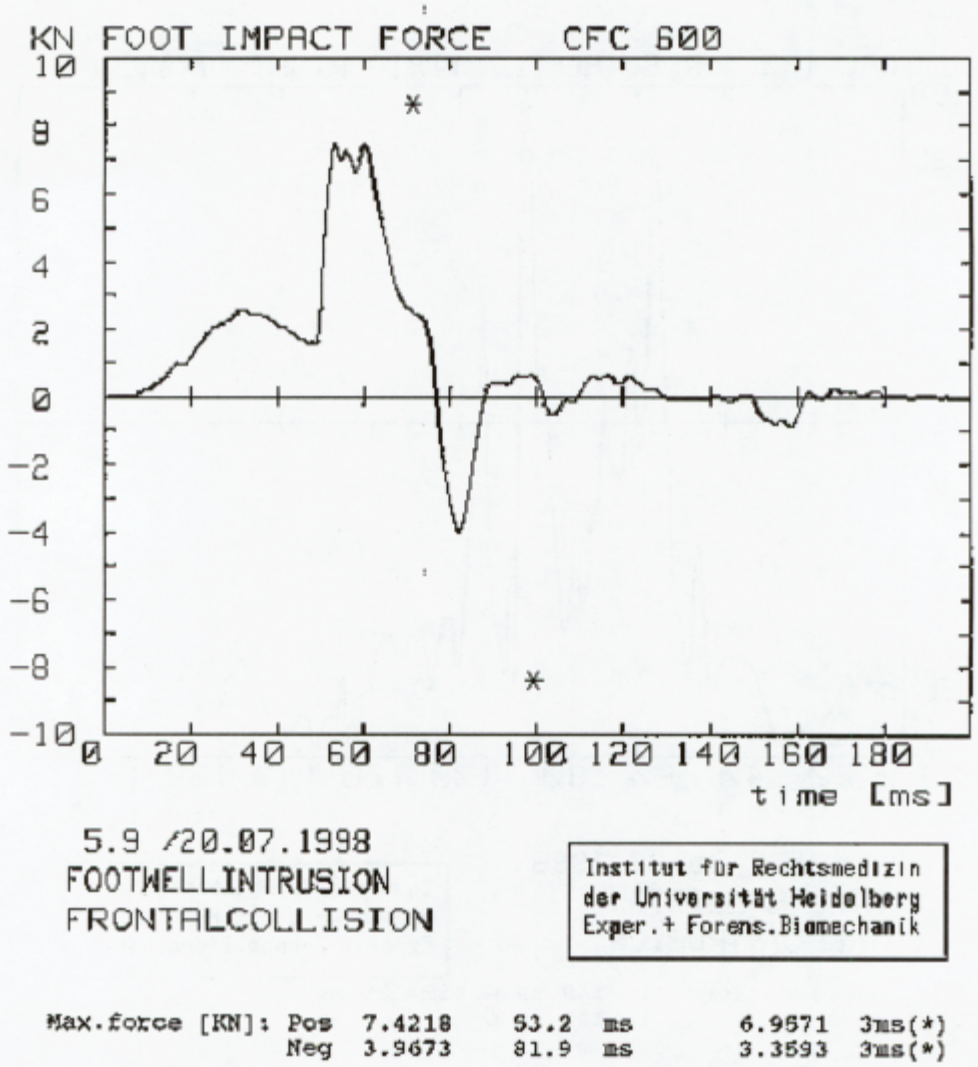


Figure 16: Resultant Acceleration at the lower tibia over time

MEDICAL FINDINGS

Right leg:

Transverse fracture of the malleolus medialis of the tibia. Cartilage crush at the front edge of the lower joint surface of the tibia in the whole width. About 5mm in diameter sized cartilage contusion at the rear lateral area of the talus. Haemorrhages at the talus joint as well as at the joint between the talus and the os naviculare. 1x1 cm sized cartilage haemorrhages at the distal tibia joint surface and the upper joint surface of the talus.

Figure 17: Transverse Fracture of the malleolus medialis of the right tibia with marks of the cartilage crush at the front edge of the lower joint surface of the tibia

Left leg:

Haemorrhage of the upper ankle joint. The front cartilage edge of the joint between talus and tibia is superficial crushed in a width of 3 cm. 1x1 cm sized cartilage haemorrhages at the distal surface of the tibia joint and the upper joint surface of the talus.

INJURY MECHANISMS

The medical findings observed are explained with dorsal flection of the foot at the ankle joint.

FUTURE RESEARCH

Additional tests with postmortem human surrogates and dummies with instrumented legs and a new data aquisition system are planned to be performed in the future.