

# Feet rolled over by cars: radiological and histological considerations from experiments

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**Abstract** This study investigates the question of whether bone structures are injured when a vehicle rolls over a foot. A total of 15 detached feet from deceased persons who had donated their bodies to research were rolled over using a VW Passat station wagon. The feet were enclosed in various types of shoes. The front left tire of the vehicle, inflated to 1.8 bar and driven at walking speed, ran over the feet at a right angle to the long axis. The feet were dissected, and histological and radiological examinations were carried out. The only macroscopically well-defined abrasions of the epidermis were on the back of the foot in the area of contact with the tire and only where the foot had not been covered by a shoe. These abrasions were also well presented histologically. No injuries to the bone structures of the feet, in the form of incomplete fractures, corticalis interruptions or spongiosa compressions were ascertained, either radiologically or microradiologically.

**Keywords** Injury through rolling over · Foot · Bone injury · Lower extremity · Traffic medicine

## Introduction

There is only one publication in the German and English literature which describes the injury pattern of feet that have

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been rolled over by a car. However, in legal proceedings, the question is often raised, whether such an event causes only soft tissue injuries or also damages the foot skeleton. Persons whose feet have been rolled over by a car are often not considered credible by the court and other parties to lawsuits regarding their account of what happened. From the viewpoint of the court and other persons, bone injuries must have been the consequence if such an event had actually taken place.

The foot exists as a support organ. Therefore, it has evolved complex bone structures that can absorb pressure. The skeleton of the foot consists of the tarsus, the metatarsus and the toes. This skeleton is covered and held together by a complex system of ligamental structures and muscles. The skin of the back of the foot is very thin and can undergo considerable displacement.

Other orthopedic and biomechanical studies with high impacts by pendulums show fractures in the area of the os calcis and the metatarsal area [5, 6].

We conducted an experimental study to determine which injuries to the foot, if any, result from it being rolled over by a car.

## Materials and methods

### First experimental series

Ten isolated feet (five left and five right) were used in the investigation and came from deceased persons (seven women and three men), ages 57–90 years, who had donated their bodies to research. The feet were sharply amputated halfway up the lower leg. The feet showed no injuries or irregularities. The footwear was of various types such as sandals, high-heels, sneakers and business shoes varying

from sizes 4 1/2 to 9. Before the rolling-over process, X-rays were taken in two levels, and the foot surfaces were digitally photographed. The feet were inserted into the footwear. They were then loaded with the sharply amputated proximal tibia and fibula bone ends into a laboratory rack and were placed on the ground. As in an actual parking situation, the feet were fixed in a vertical axis only.

For the rolling-over process itself, a typical parking situation was simulated and recorded on video. Using a VW Passat station wagon (1,350 kg). The front left tire of the vehicle, inflated to 1.8 bar, was driven at walking speed, running over the feet at a right angle to the long axis. The experiments were performed on asphalt with an average speed of about 0.3–0.5 m/s.

Subsequent to having been rolled over, the foot surfaces were digitally photographed again (Fig. 1). X-ray pictures were taken in two levels. The feet were macroanatomically dissected in layers. Proximal, medial and distal strips of skin, along with subcutaneous fat tissue, covering the entire back of the foot and about 1 cm wide were removed from the roll-over zone of each foot and were placed in formalin for histological staining. The examination of the skin strips took place in serial slices. Both hematoxylin and eosin and elastica van Gieson stains were performed.

#### Second experimental series

For the second experimental series, five more injury-free feet from deceased persons (two women and one man) who had donated their bodies to research, ages 65–93 years, were rolled over, three left and two right feet. The feet were again put into various footwear such as sandals, high-heels, sneakers and business shoes varying from sizes 4 1/2 to 9. There were no external injuries or irregularities of the foot surfaces. The rolling-over process took place analogously to the first experimental series. Before and after having been rolled over, X-rays of the feet were taken in two levels, and the foot surfaces were digitally photographed.

**Fig. 1** Digital photograph of the running-over zone of the unshoed back of the foot after the running-over process



After the rolling-over, the isolated feet were deep-frozen at  $-20^{\circ}\text{C}$  and then sliced into 4-mm thick sections with a band saw (Reich, Remshalden, Germany) with a saw blade length of 3,350 mm. These preparation sections were microradiologically imaged at 40 kV, for an exposure time of 30 s, on Structurix D4DW Film from Agfa, with an X-ray machine from the series Hp Carbinet X-ray System Fraxitron, Modelnumber 43855A (Fig. 6). Next, there was an evaluation of the X-ray results using a conventional X-ray viewing screen regarding fractures, incomplete fractures, structural damage of the compacta and spongiosa compressions.

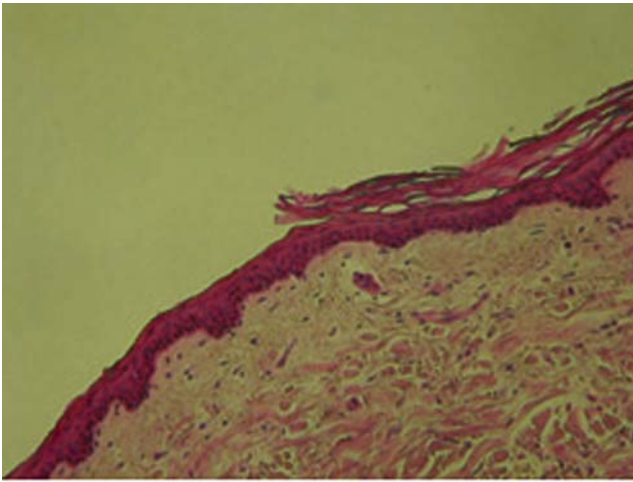
## Results

#### First experimental series

Injuries caused by the rolling-over process were found only in the area of the back of the foot that was not covered by footwear. In five out of ten feet, there were superficial abrasion with epithelial shredding in the area of the foot not covered by footwear (Fig. 2). Also, there was soiling in the area of the contact zone, which was caused by the car tire. The dissection did not reveal any macroanatomical irregularities in the soft tissues. The dissections and X-rays showed no damage to the bone structures. The histological staining of the skin strips presented clearly the superficial abrasions as abrupt interruptions and loss of the epidermis (Fig. 3). The formation of epithelial shredding was presented just as clearly (Fig. 4). Beyond that, there were only microscopically demonstrable interruptions of epidermis, which looked as if they had been punched out cleanly, with damage to the underlying tissue layer (Fig. 5). No alterations of the tissue caused by decay were found in the histological examination.

**Fig. 2** Superficial abrasion in the area of the running-over zone with soilings





**Fig. 3** Histological presentation of the superficial abrasion (HE)

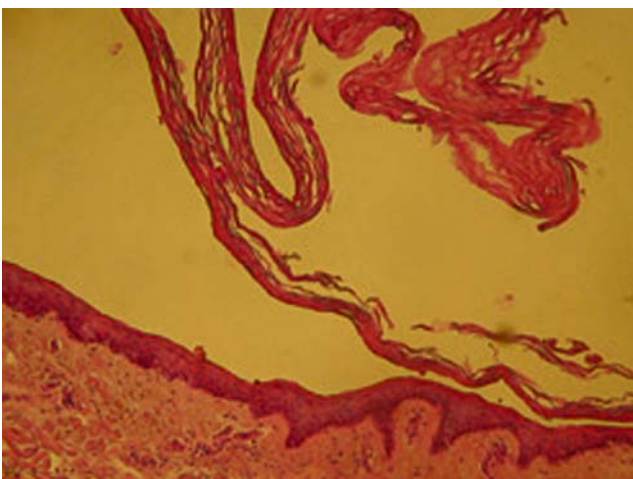
### Second experimental series

After the rolling-over process of the second experimental series, again only injuries in the sense of superficial abrasion appeared in the area of the back of the foot not covered by footwear. When the back of the foot was covered by a shoe, no definable irregularities appeared in the skin surface.

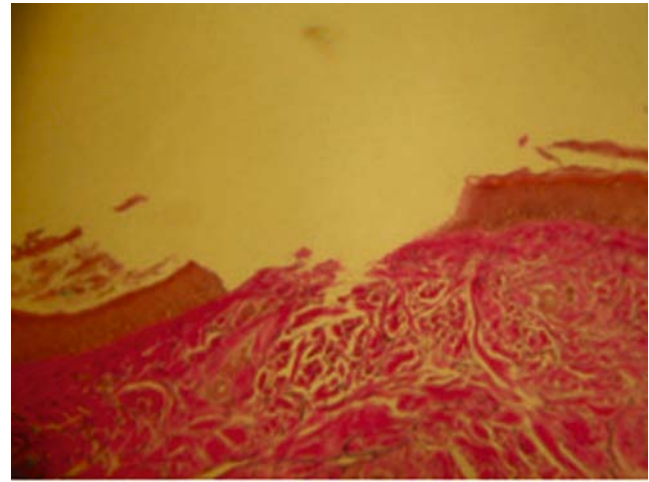
Microradiologically, there was no damage to the bone structures in the form of fractures, incomplete fractures, corticalis interruptions or spongiosa compressions (Fig. 6). Thus, microradiologically, there was no indication of any injury to the bones.

### Discussion

In the practice of legal medicine, we are occasionally asked for expert opinions on incidents involving feet that have been rolled over by the tire of a car. The case constellation is



**Fig. 4** Histological presentation of the epithelial shredding (HE)



**Fig. 5** Histological presentation of the epidermis defects (HE)

almost always the same. One scenario is that a person wants to keep a parking space free for someone else, and another car driver then aggressively forces his or her car into this parking space at walking speed, whereby occasionally, the foot of the person holding the parking space free is then rolled over. Another background story frequently presented is that the injured person was trying to direct a car into a tight parking space and inadvertently his or her foot was rolled over. What is common to both of these most frequently given case constellations is that it is predominantly a matter of slow speeds, and in the majority of cases, feet with shoes are rolled over. Up to now, we know of no cases in the testimony practice of expert witnesses in which bone injuries or even any other substantial injury occurred. When the persons subsequently report it to the police or try to sue for compensation for injuries, they are often not considered credible by the police or the courts. The general opinion seems to be that the process of being rolled over by a car tire must necessarily cause severe traumatization, including bone injuries. The fact that the victim reports only pain and a reddening of the back of the foot, occasionally accompanied by a superficial grazing or quite rarely a larger hematoma,



**Fig. 6** No damage of the bone structures of the foot in the microradiological X-ray recording

regularly gives rise to considerable scepticism among the lawsuit participants.

Our experience with such cases, as well as the experimental investigations presented here, indicate that a rolling-over process with a slowly moving car does not result in bone injuries or even any other substantial injury if the feet in the experiment were clothed with footwear, in which case even superficial skin abrasions were absent. Our experimental data conform to the actual cases examined by us, in which the rolling-over of the foot was definitively verified through the police inquiries, investigations of tracks, and/or eye-witness reports. Also in the majority of these cases, only temporary pain sensation, restriction of movement and reddening were described, all of which healed completely. Bone injuries were not found in any of these cases and there were also no injuries to the ligaments.

We assume that the decisive factor is vehicle speed and the position of the foot in relation to the vehicle tire at the time of being rolled over. At higher speeds and different positions of the foot, injuries of deeper structures of the foot would be expected from a corresponding process [7].

In this study, we intended to show that a foot that is rolled over by a tire of a car at low speed need not automatically show bone injuries. The question of describing the circumstances and velocities at which injuries to the foot skeleton take place and the development of a fracture threshold will be topics of further experimental series.

So far, a study by Al-Qattan [1] seems to confirm our experimental considerations as well as our real cases. Al-Qattan presented a case collection with a total of 25 children in which the accident mechanism was the same for all children: After the vehicle tire made contact with the feet of the children, the driver instinctively tried to brake. Thereby injuries of various degrees of severity occurred in the form

of abrasions and bone injuries, depending on the velocity of the vehicle and the position of the foot at the time of being rolled over. Other studies with different but similar mechanisms are also pointing in the same direction [2–4].

## Conclusion

The lack of bone injuries or other serious injuries of the foot do not exclude the foot having been rolled over at low speeds by a motor vehicle. Rather, bone injuries are not to be expected at low speeds.

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