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Foot Injuries in Car Occupants

The improvement of passive car security devices led to a reduction of injuries, especially of the head, the neck and the torso mainly due to the airbag function. The passenger's foot and ankle could not profit from this development. Some investigators even reported a progression of leg injuries (1).

In this study, we investigated a current collective of patients with foot and ankle fractures or severe soft tissue injuries in relation with defined crash parameters. Special interest was paid to the car's footwell.

Patients and Methods

We analyzed retrospectively a data set of car accidents, collected by the accident research team of the Technical University of Dresden, regarding the passengers foot and ankle injuries. The investigated period took place from July 1999 to December 2002. The data collection was followed by a spot check with following criteria: car accident with injured people, during a predetermined time and area. The observed area covered 2575 square kilometres with 925,000 inhabitants. 500 to 3000 data items were collected for each accident. Afterwards, the accidents were virtually reconstructed by a specially designed computer program. In this study, we included all front seat passengers of four wheel cars (inclusive buses and lorries), which suffered a foot or ankle injury directly due to the accident with an AIS (abbreviated injury score) ≥2. Exclusion criteria were a rollover or an extricated passenger.

AIS (abbreviated injury score) for lower extremity (2):

AIS 1 – toe fractures, minor to moderate soft tissue injury

AIS 2 – foot fractures, except severely dislocated or comminuted fractures (compare AIS 3), severe soft tissue injuries

AIS 3 – dislocated fractures of the ankle with a Volkmann triangle, Chopart-Lisfranc dislocation fractures, most severe soft tissue injury, traumatic amputation

These criteria were fulfilled by 2221 injured people from a total of 5218 persons involved in the recorded car accidents. For clearer demonstration purposes, we divided the foot in its anatomic regions: ankle, hind-foot, mid-foot and fore-foot. We investigated the main impulse direction of the car accident, the change of speed (delta-v inkm/h), the EES (energy equivalent speed inkm/h), the degree of footwell intrusion and the injury causing parts.

Results

Fourty persons suffered in 34 accidents a foot and/or ankle fracture with an AIS ≥2, corresponding to 1.8 percent of all registered injured persons. The mean age was 41.7 years (range 17-75 years). Men were injured three times more than women (31 men, 9 women). These 40 persons had, all in all, 49 distinct foot and/or ankle fractures. The distribution of these injuries is shown in figure 1.

33 persons were injured as drivers, 7 as passengers. 10 patients had a polytrauma, of whom 6 died.

5 patients had series fractures, 4 patients had fractures on both feet. We saw open injuries in 4 cases. The outer foot was as often injured as the inner.

All cars were equipped with belts, 8 patients were not belted. 8 cars had an airbag, in 7 cases the airbag was activated. We observed 12 accidents between two cars and 22 accidents between a car and a solid obstacle like trees or buildings.

We recorded 4 different accident places (figure 4).

The accidents were caused by frontal crashes in 93 percent of the cases: The main impuls direction came from 11h in 20 percent, 12h in 63 percent and 1h in 10 percent.

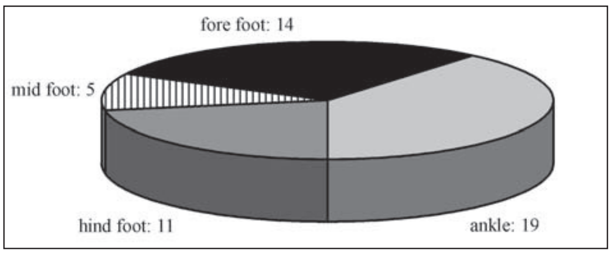

Fig. 1: Distribution of fractures and luxations to the anatomic regions of foot (n = 49)

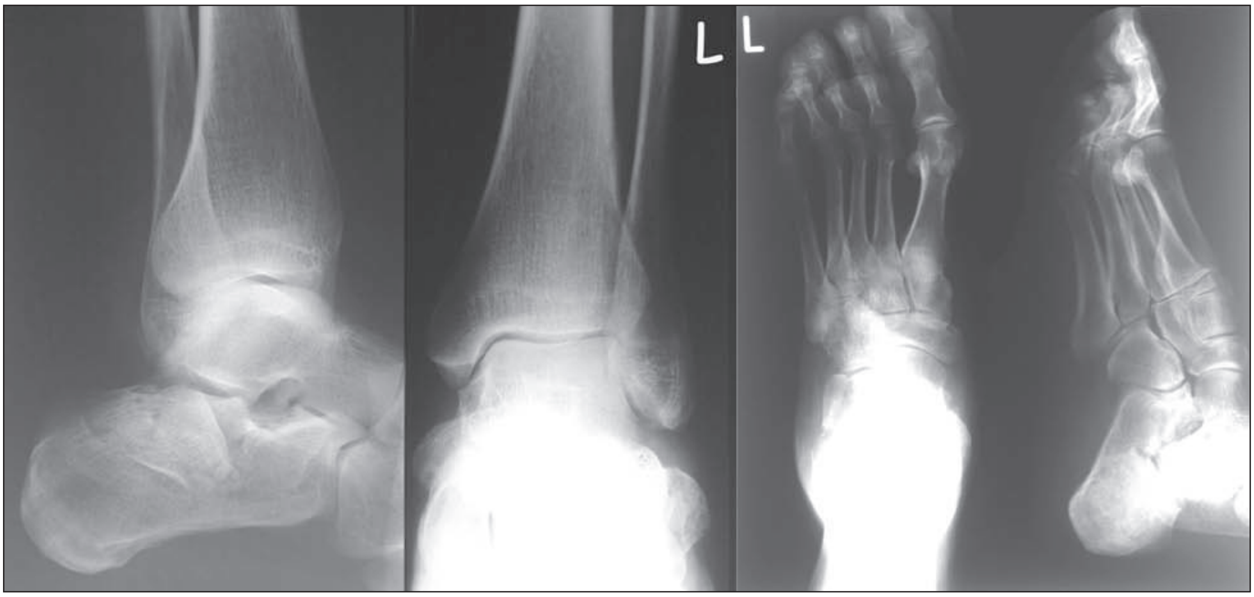

Fig. 2: Calcaneus fracture, delta-v 20km/h, small car type

Fig. 3: Talus fracture, delta-v 75km/h, small car

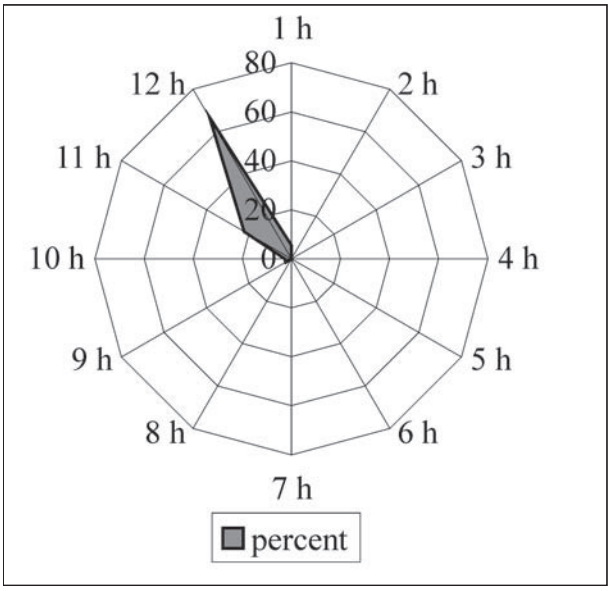

Fig. 5: Main impulse direction

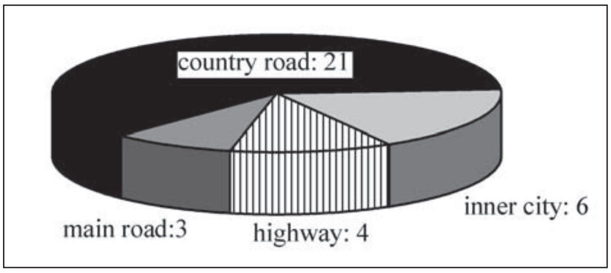

Fig. 4: Place of accident (n = 34)

Fig. 6: Frontal crash (car of compact class type, main impulse direction from 12h)

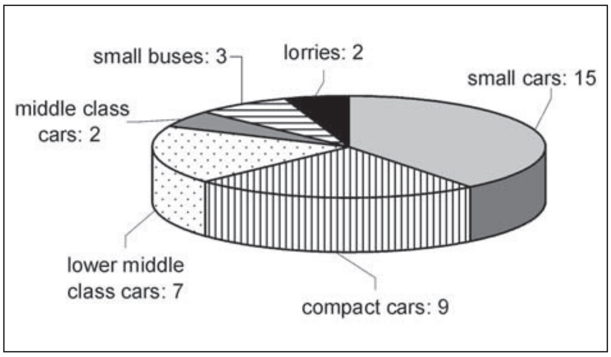

Fig. 7: Car types (n = 38) in which patients suffered by foot and ankle fractures

The noticed foot/ankle fractures happened in 38 cars (distribution see figure 7). The main age of the cars was 8 years, 7 cars were older than 10 years.

We saw no different in delta-v and EES-levels between the different foot/ankle anatomic regions (see figure 8).

The footwell intrusion was measured in different regions of the car`s body. There is a trend to higher intrusion levels in sector L1-left in ankle- and hind-foot fractures (see figure 9).

High intrusion levels seemed to produce more often ankle and hind-foot fractures than mid- and

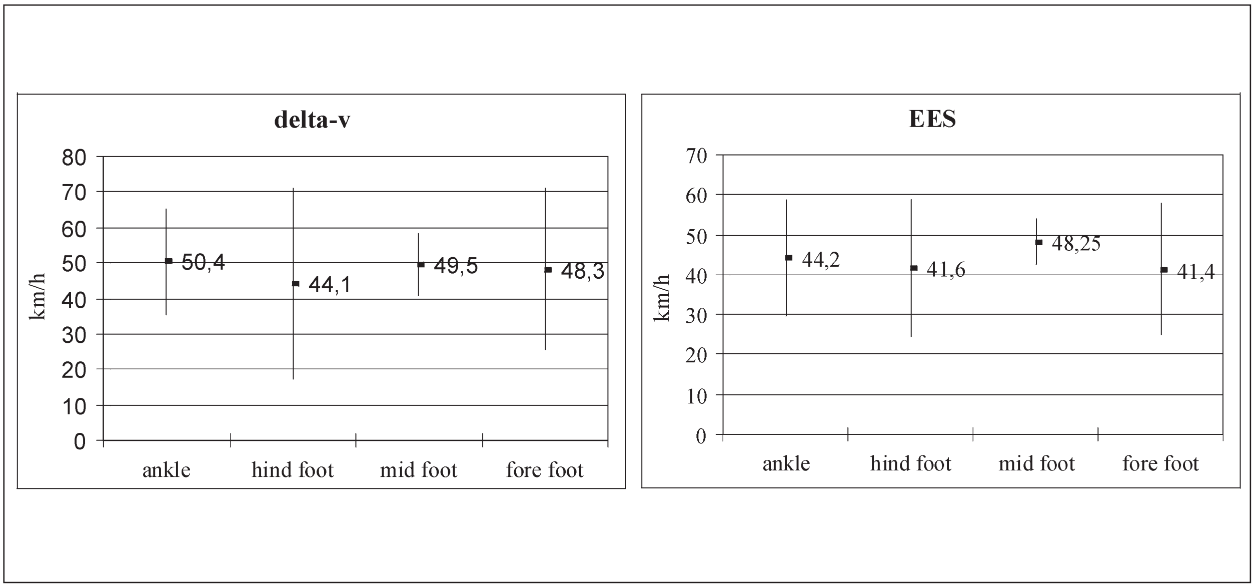

Fig. 8: Delta-v- and EES-level assigned to injured foot regions

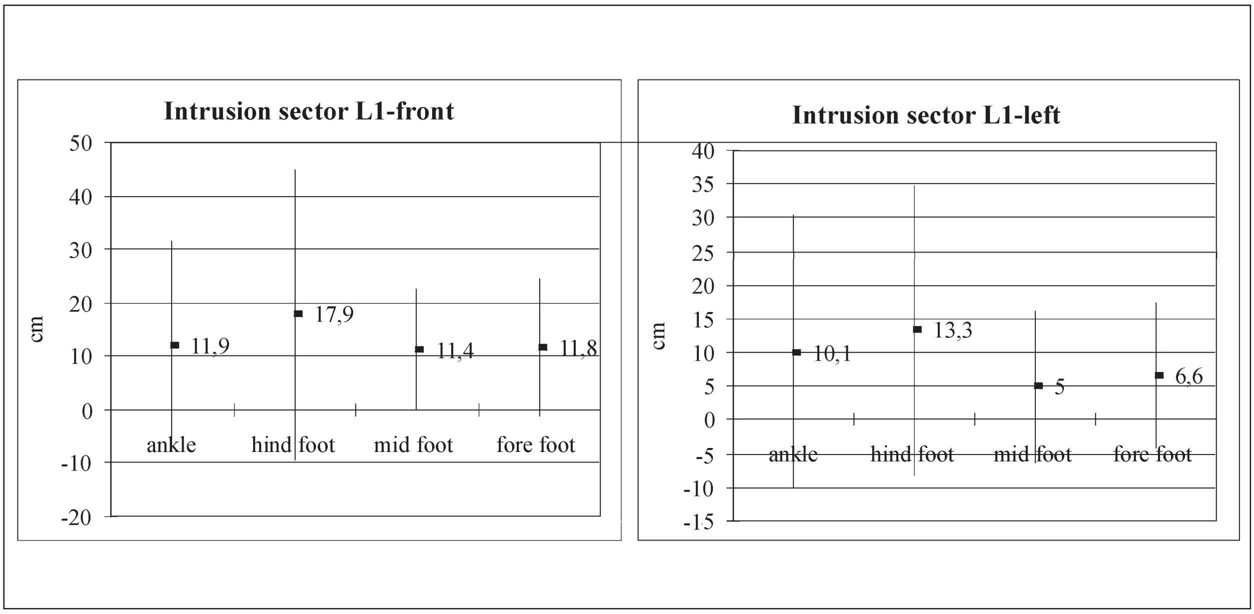

Fig. 9: Footwell intrusion sector L1-front and L1-left assigned to injured foot regions

fore-foot fractures. In cars with low footwell intrusion (≤10cm) three of 20 injuries were AIS 3-injuries, but in cars with high footwell intrusion (≥40cm) 7 of 14 injuries were AIS 3-injuries.

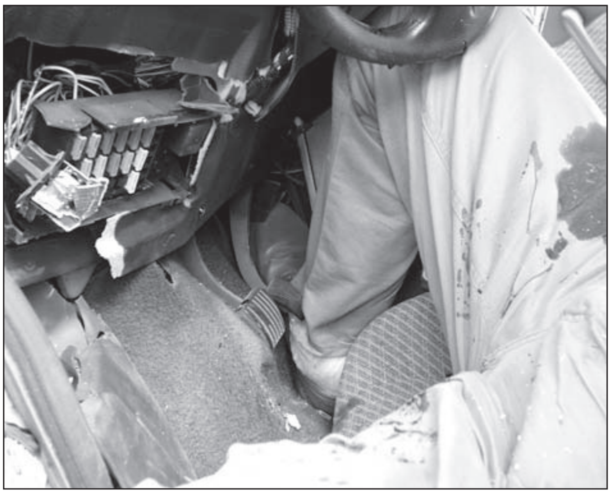

Fig. 10: Typical accident mechanism with squeeze of the foot. Man, 42 years, car of lower middle class; death due to ruptur of liver and spleen; fractures of 2nd to 4th toe, severe soft tissue injury of right foot. Footwell intrusion in sector L1 front of 30cm, in sector L2 front of 20cm, delta-v 75km/h

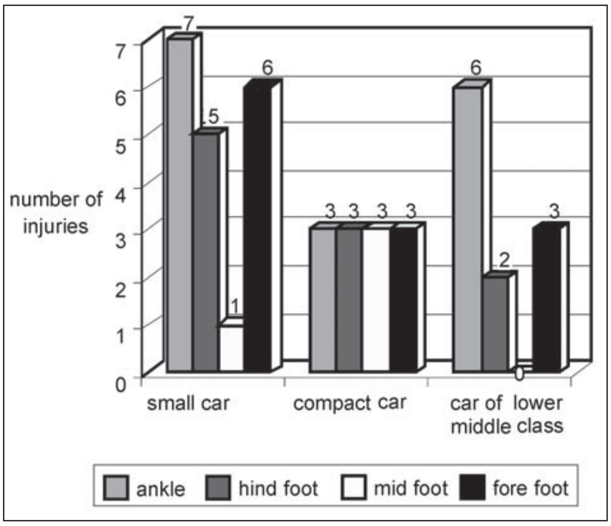

Fig. 11: Foot injuries assigned to different car classes

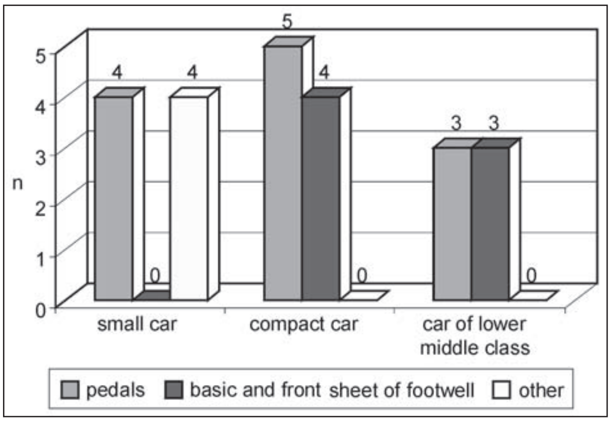

Fig. 12: Injury causing parts in different car types

We investigated the frequency of foot/ankle fractures in different car types and found a tendency of more frequent ankle injuries in small cars and cars of lower middle class (see figure 11).

The fractures mostly were caused by the pedals (see figure 12).

Conclusions

Foot/ankle fractures are seldom injuries (1.8 percent of injured persons). They are a typical drivers injury (driver : passenger = 4,5:1). Often we see these fractures in patients with polytrauma (n=10 of 40, 6 patients died). Foot/ankle fractures mostly happen in frontal crashes in cars of small dimension. High intrusion levels seem to produce more often ankle and hindfoot fractures than mid- and fore-foot fractures. The fractures are mostly caused by the pedals.

References

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