Parametrization of Pedestrian Injuries and Its Utilisation in Proving Traffic Accidents Course

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Abstract

This paper deals with the unique FORTIS system for parametrization of injuries, which allows one to make the scoring of injuries resulting from accidents, while it offers possibilities for its utilisation for the needs of the road transportation experts or biomechanics during the analysis of vehicle - pedestrian accident cases or for forensic biomechanical assessment of a course of other accidents. The work presents forensic investigation of fatal injuries of pedestrians and an assessment carried out via the FORTIS system in comparison with AIS. The output is a complex parametrization of accident consequences that can be used for the needs of traffic accident analysts and experts in other forensic sciences in calculations in a simulation program or using other forensic exact methods.

Key Words: *Injury, description of injuries, injury parametrization system, injury localization, collision analysis*

Introduction

Nowadays, an expert in the field of road transport as well as an expert in the field of forensic biomechanics has considerably limited possibilities to use the information on a type, extent or exact location of an injury in the assessment of an accident or an injury case. This is due to the fact that usually it is only a verbal description of injuries carried out by a doctor, but the form of such information is only a small help to expand the necessary knowledge about a movement of an injured person and a particular way the injury was caused.

For further investigation of the possibilities to use the injury parametrization and localization of injuries in practice the „Theory of injury and contact signatures“ was used, which was prepared by forensic engineers in cooperation with the (Institute of Forensic Medicine of P. J. Šafárik University in Košice, Slovakia) in the past years (since 2002) based on the theoretical evaluation of the simulation results of 250 traffic injuries and about 200 actual accidents.

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Pedestrian injuries as an information on the course of the collision

In this respect, the primary parameters were particularly

- location on pedestrian’s body (injury location), resulting from the first contact with the vehicle

- extent of injuries (consequence of collisions) determined on the basis experts forensic assessment

It is obvious that the distinctness of every injury or accident plays a decisive role here as the localization, the type and extent of injuries in connection with the localization and the type and extent of damage to a vehicle provide a specific picture of a collision, the „ reading“ or recognition of which would, together with other data, significantly improve the collision analysis, eliminate the current inaccuracies and scholastic phenomena.

The following question may be raised in relation to the above:

"How to use the information on injuries sustained by the pedestrian during the sequence of impact, after "throwing" and movement to final position in the crash analysis, provided that the injuries cannot be sufficiently measured at the level acceptable for calculation purposes"

Additional two methodological questions arise when we attempt to answer the question:

1. How to express the location, extent and type of pedestrian injuries (in general – consequences of violence acting upon human body resulting in the injury), to enable any degree of quantification, whereas the quantification should be correct especially from medical viewpoint, as performed by forensic specialists?

2. How to make use of this forensic quantification to assist in the analysis of traffic accidents?, i.e. how to transmit and subsequently use the knowledge from the two fields – forensic medicine and forensic engineering to analyse the sequence of the accident?

Provided that a collision and an injury are, physically speaking, a unique and unrepeatable set of phenomena, which is affected by an undefined number of influences, out of which many are specific for a particular collision, we may predict that in order to achieve the best solution for its analysis it is vital that we make use of all known circumstances and facts.

Parametrization and determination of injury extent from medical point of view – current state

The effort to standardize injuries to a human body (including pedestrian injuries in traffic accidents) is motivated by a need to define causes and consequences of injuries. During an interaction of a human body part and a vehicle (or a vehicle interior, a road, a motorcycle, etc.) there are mechanical and physiological changes of the contacting human body parts due to the action of force. These changes are called a biomechanical response to an external load[5].

To describe the dependence between a mechanical (time and force) action and a biomechanical response for the needs of technical experts it is necessary to define the criteria that express a degree of an estimated biomechanical response to a mechanical load. The extent of injuries may help to reconstruct the course of an accident and it also may be a very useful control value.

The AIS/ISS injury scale is currently considered a classic injury parameter evaluation system from the medical point of view. The mentioned parametrization is based on the medical esvaluation of injury type and extent.

Methodology of injury severity score AIS/ISS

The point values according to *Abbreviated Injury Score* (AIS) and *Injury Severity Score* (ISS) for injuries (adapted according to *Baker et al.*, 1974, 1984, *Moore et al.*, 1998):

AIS point value of one body part	Injury description	ISS value (AIS2)
0	No injury	0
1	Minor injury	1
2	Moderate injury	4
3	Serious injury	9
4	Severe injury	16
5	Life-threatening injury	25
6	Fatal injury	36

ISS = AIS2 max1 + AIS2 max2 + AIS2 max3 (0 … 75 points)

Among other well-known there are GSI (Gadd Severity Index), HIC (Head Injury Criterion – a head injury parameter), 3MS, TTI (Thoracic Trauma Index – a trunk injury parameter), VC (a soft tissue injury parameter), EIC (Extended Injury Criterion – an extended injury parameter), which are the ways of injury parametrization, but they provide a universal information means neither for the entire body of an injured person nor for all types of injuries.

Parameterization of injuries in crashes involving pedestrian injuries – FORTIS system (Forensic Traumatology Injury Scale)

Nowadays, a forensic analysis of injuries, especially traffic injuries, is not always standard, mainly due to the lack of an established, precisely defined procedure of injury parameter standardization. The proposed

procedure for the assessment of traffic injuries, including the key element of injury parameter standardization according to internationally accepted AIS/ISS scale (Abbreviated Injury Scale/Injury Severity Score) is as follows:

Materials and Methods

- Investigated circumstances, accompanying documentation, autopsy reports, image documentation and results of supplementary investigation evidence from traffic accidents involving pedestrian fatalities

- Completed autopsy report in accordance with the requirements of International Disease Classification (10th revision)

- Assessment of injury parameters using proprietary modified FORTIS system, comparison of FORTIS values with AIS/ISS values

The modified FORTIS system

The result is the modified FORTIS system – a range of injuries in forensic traumatology, the use of which enables a more complex expression of the severity of an injury, thus enabling its further use to solve traffic accidents and other injury events resulting in damage to health. The FORTIS system uses a proprietary modified point value system, which besides determining the basic injury to health (ZPZ), proposes classification of accompanying complications in two groups: Ko1 - primary post-injury complications - such as traumatic shock, haemorrhagic shock, cardiac tamponade, haemothorax, pneumothorax) and secondary complications Ko2 – such as inflammatory changes, oedema of non-traumatic origin, thromboses, conditions arising from surgeries, etc.

Such division provides an opportunity to indirectly assess quality of healthcare provision in case of a surviving injured. To verify the proprietary modified **FORTIS** system, 12 fatal traffic accidents were subjected to assessment by forensic pathologists, evaluating each case as a single event and subsequently each relevant item in the autopsy report was assessed in a similar way. The results acquired through above analysis were compared to standard assessment of injury parameters – AIS/ISS in order to demonstrate new possibilities of the **FORTIS** system in quantification of injury parameters.

Point values of the 12 assessed pedestrian fatalities using standard AIS/ISS method and the modified FORTIS system can be seen in table 1.

Table 1: Scoring of traffic accidents of pedestrians, using classical methodology AIS/ISS and respective modified FORTIS system

Case No.	Name, age	M/W	Vehicle	Survival period (hour)	ISS	FORTIS total	FORTIS ZPZ	FORTIS Ko1	FORTIS Ko2
1	P.U., 41	M	Van	0	66	44,1	22,4	11,7	13
2	M.J., 38	M	Car	0	75	82,8	47,7	16,1	19
3	A.P.,67	W	Car	0	75	78,2	53,6	17,6	7
4	E.P., 9	M	Car	0	75	57,1	41,1	9	7
5	P.S., 49	W	Truck	0	75	66,3	65,3	1,0	0
6	A.Č, 80	M	Car	0,8	57	83,2	66,2	12	5
7	J.N., 58	M	Car	2	75	97,4	77,4	7,3	12,7
8	J.B., 57	M	Car	24	75	99,2	60,8	20,7	17,7
9	I.M., 47	M	Car	72	75	102,7	46,9	16,1	37,7
10	Š.Ch.,57	M	Truck	239	75	59	19,1	14,5	25,4
11	F.K., 51	M	Car	288	75	27	9,3	7,7	10
12	M.P.,39	M	Car	291	75	60,8	24,2	8,5	28,1

It is undeniable that the possibilities of the point injury evaluation by the **FORTIS** system are wider; the system is more flexible, more accurate and it differentiates a degree of damage to health caused by the injury, which was fully confirmed by a research focused on the possibilities of using the proposed system.

Illustrative examples of scoring of forensic examination of fatal injuries with a different ratio ZPZ, Ko1 and Ko2

A. Results - case No.4

Investigated circumstances: involving motor vehicle VW Passat, whereas the vehicle with its right side collided with underage pedestrian who entered its trajectory from the right side, causing him head injury to which he succumbed shortly after the accident.

Immediate cause of death: Rupture of the connection between medulla oblongata and cerebral pons and contusion and laceration of brain and intracranial haemorrhage resulting from fragmented fractures of cranial calvaria and base.

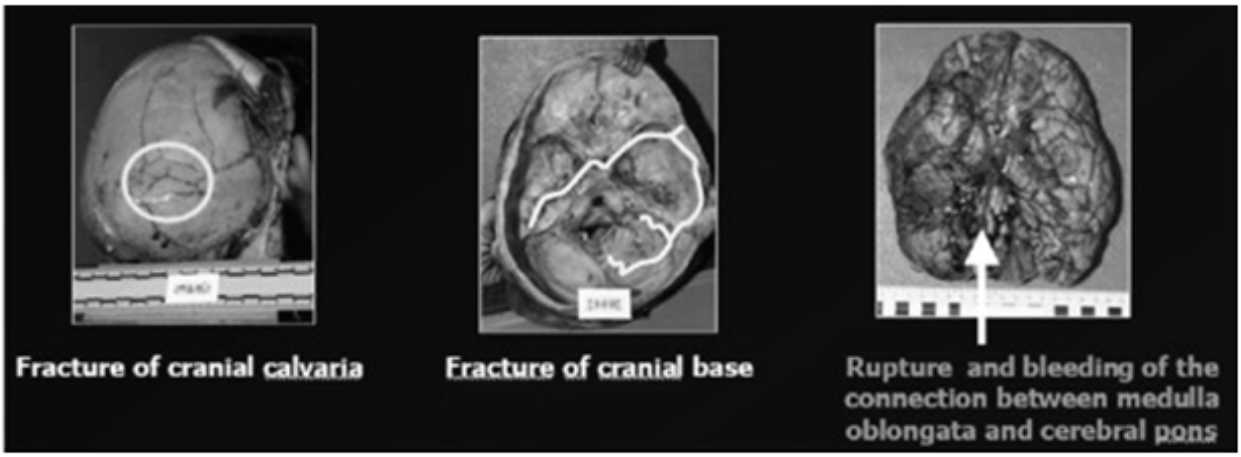

Fig. 1 Documentation of finding - illustration to case no. 4

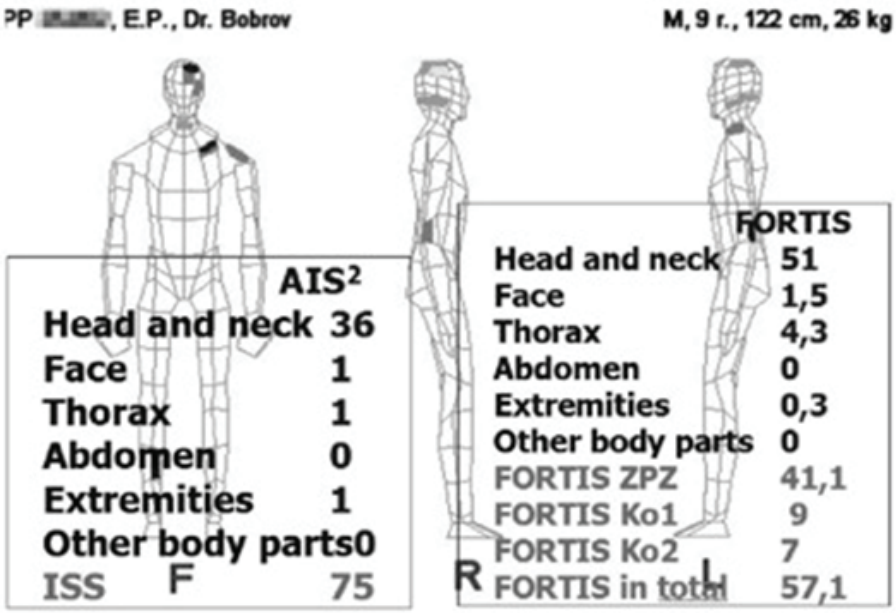

Fig. 2: Evaluation of parameters of injuries in the case no. 4 via custom modified FORTIS system and comparison of FORTIS values with AIS/ISS values

B. Results - case No.11

Investigated circumstances: involving a collision between passenger vehicle and pedestrian. The injured pedestrian was subsequently hospitalized at the traumatology department with bilateral fracture of pelvis (treated by conservative – Kirschner´s extension of left leg). On the 12th day of hospitalization, F.K. died.

Immediate cause of death: Bilateral focal catarrhal-purulent broncho-pneumonia.

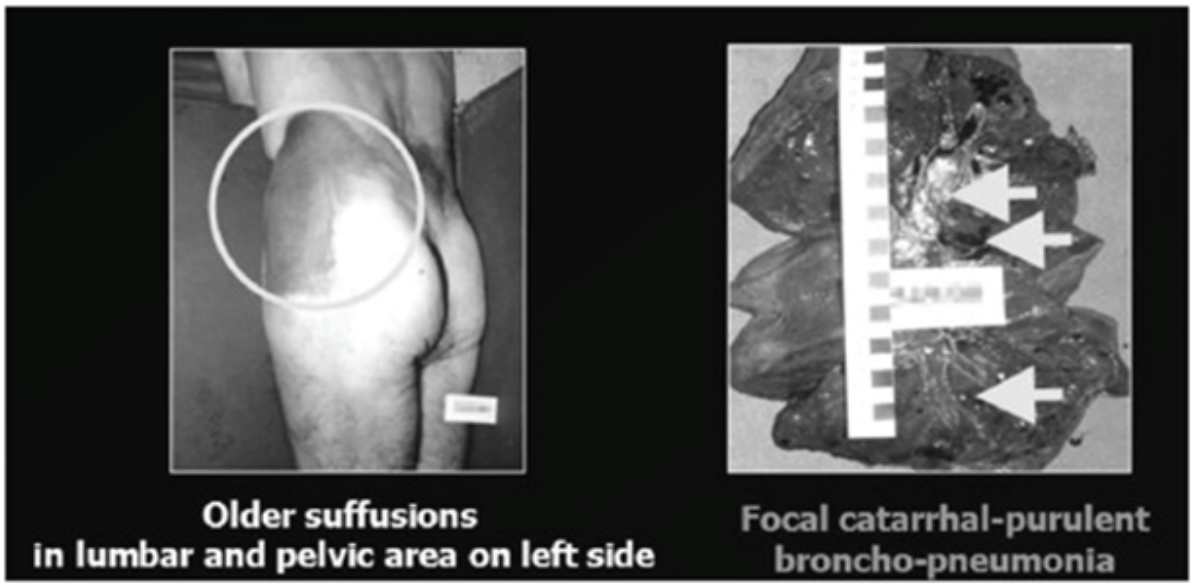

Fig. 3 Documentation of the finding - illustration to case no. 11

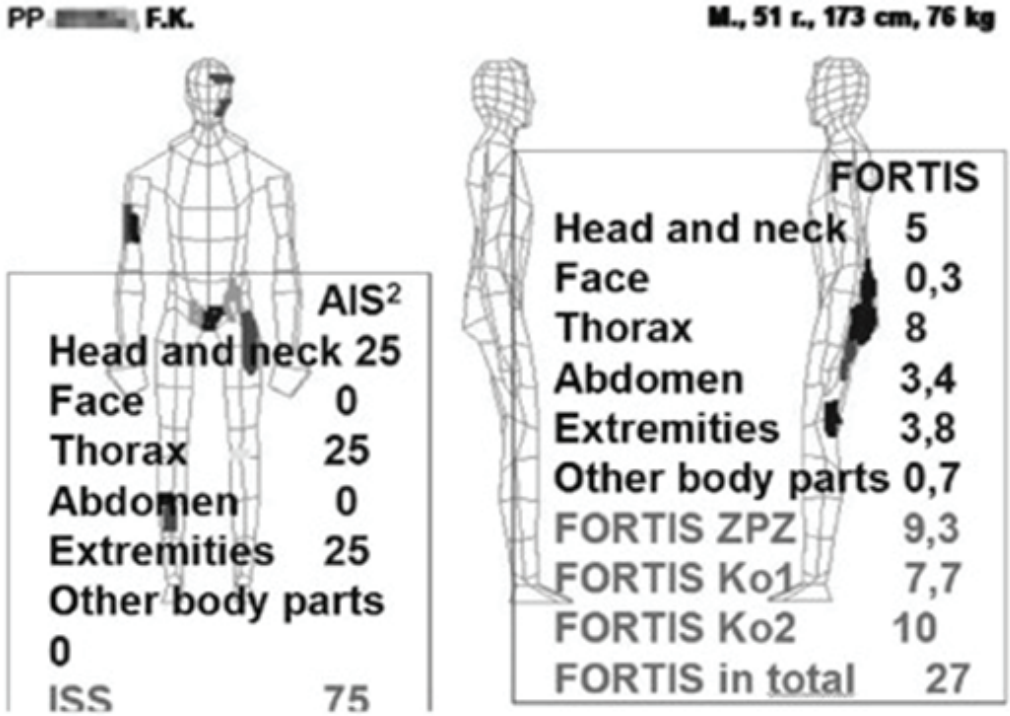

Fig. 4 Evaluation of parameters of injuries in case no. 11 via custom modified FORTIS system and comparison of FORTIS values with AIS/ISS values

EVALUATION AND BENEFITS OF FORTIS SYSTEM

The informative value of the modified FORTIS system according to the extent of the damage to health in connection with the immediate consequences of the actuating violence (ZPZ – basic damage to health) and associated complications (Ko1, Ko2) in the selected cases, case No.4 and case No. 11, in relation to the survival period of the injured persons is shown in Fig.5 and Fig.6**:**

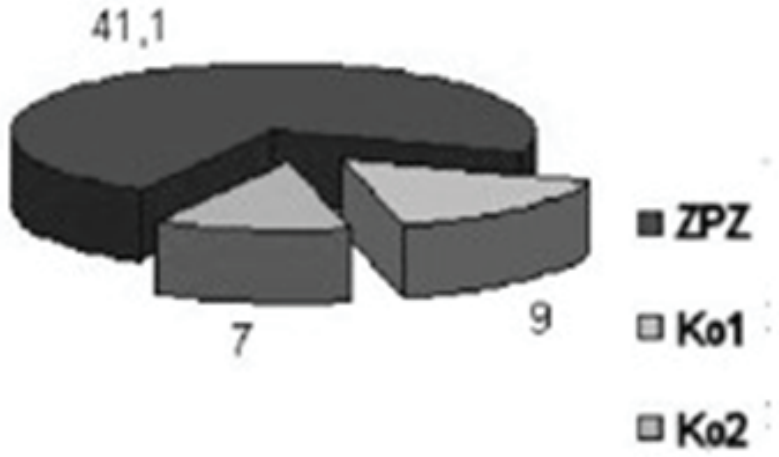

Fig. 5 Relationship of FORTIS ZPZ, Ko1 and Ko2 in the event of death on the spot DN- case no. 4

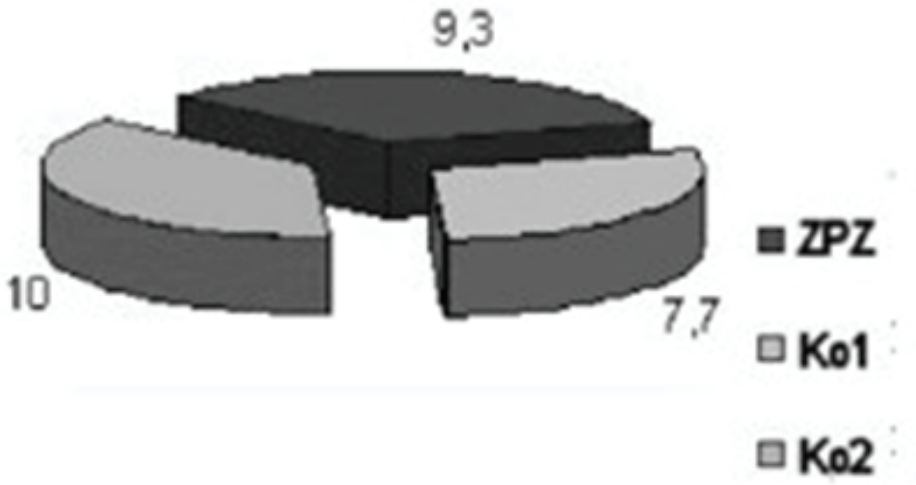

Fig. 6 Relationship of FORTIS ZPZ, Ko1 and Ko2 in the event of survival - case no. 11

The research conducted so far, outcomes of which are presented herein, enables us to state that the technique of standardization of pedestrian injury parameters in case of traffic accidents (quantification of injuries) requires the application of the proprietary modified scoring system **FORTIS,** that enables (subject to good quality of input parameters) to calculate the degree of the basic injury to health, primary post-injury complications and secondary complications, including painful treatment procedures and poor quality of healthcare and in case of fatal injuries it enables to determine the immediate cause of death.

The modified system of injury scoring differs from the existing systems in the following aspects:

FORTIS vs. AIS/ISS

Scoring of injuries and their complications using modified tables Injury Score in Forensic Medicine

- Special scoring of the basic injury to health (ZPZ)
- The complications are divided in two categories:
  1) primary post-injury complications (Ko1)
  2) secondary complications (Ko2)
- The score values include decimal positions
- Maximum score of FORTIS is not limited

It is clear that the above mentioned differences between FORTIS and the scale of the AIA/ISS system significantly increase FORTIS´s utility, accuracy resulting in certain parameter of the injury expressed in the form of a number, enabling the generation of characteristic signatures with respect to the parameters of the collision between the vehicle and the pedestrian, or in general to the mechanism of injuries.

Currently, the total number of 39 tables of individual body parts is being processed with regard to decisive health consequences in relation to the extent and location of the actuating violence, which are gradually verified and completed with others. The stated methodology continues to be constantly improved.

In order to manage a full use of **FORTIS** system for the needs of the accident course analysis (or the injury course analysis) it is necessary to display the localization of the spot on the body surface, where the violence resulting in an injury actuated. Then, we may compare this localization with the localization of the contact according to a calculation in the simulation program, as shown in Fig.7.

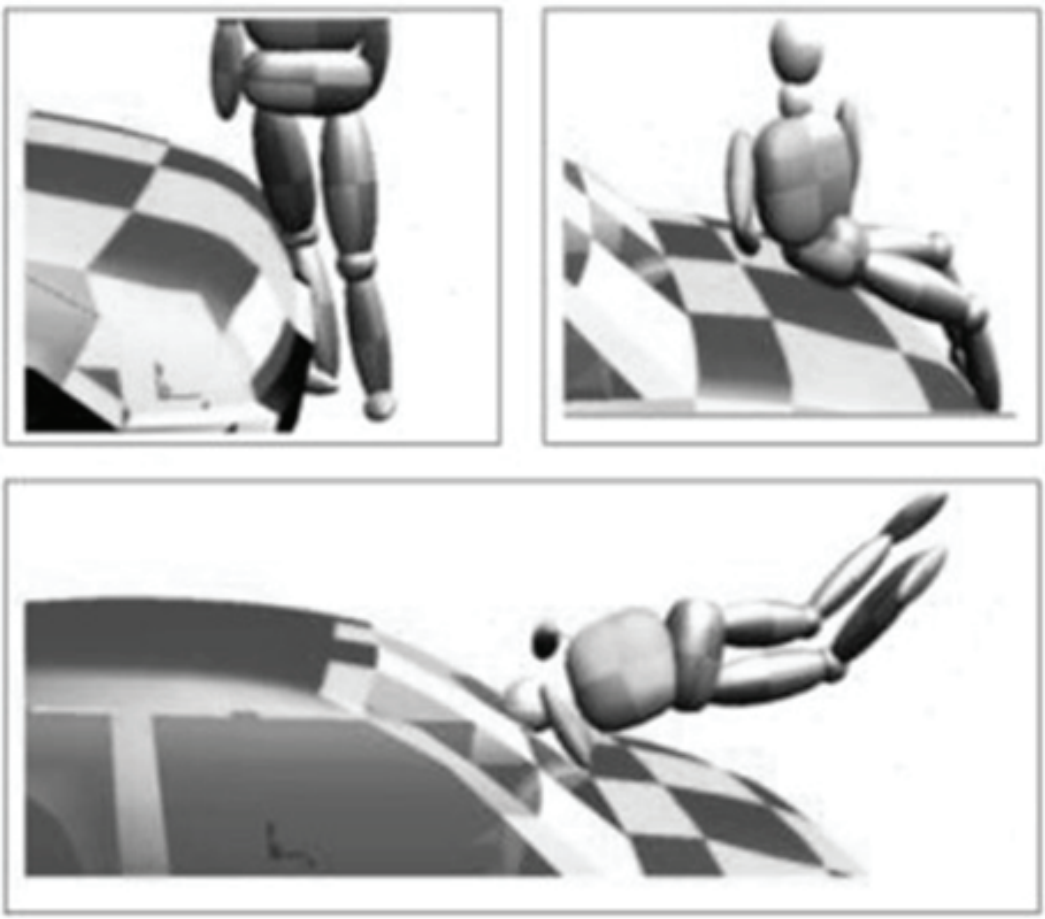

Fig. 7 Examples of visual identification of contacts in PC Crash program [3]

Conclusion

It is apparent that in such way we created an opportunity, for the needs of analysts of traffic accidents at solving the vehicle-pedestrian collision, sto compare a level of concordance of localisation of injuries at own calculations, and even by comparing the concordance of distribution of total energy acting upon collision to the pedestrian's body, using calculation program. The said FORTIS system has considerably greater possibilities of use within forensic medicine and traumatology as it includes not only the area of evaluation of road traffic injuries, but also all injury phenomena (railway accidents, aviation accidents, violent criminal acts, etc.), during the analysis of which it is possible to obtain the information on severity of individual traumatic contacts for individual calculations, than the simulation programs used to analyse traffic accidents. We may presume that the FORTIS system should be already used in the first contact between a doctor and a patient suffering an injury and that it should accompany the patient until he/she recovers and that it should also be used to investigate the accident/injury as well as for a legal assessment of all its aspects, for which it provides all available information for the mentioned said purpose.

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