UNIVERSITATEA DE MEDICINA ȘI FARMACIE
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FORENSIC IMPLICATIONS OF OSTEO-ARTICULAR INJURIES PRODUCED IN TRAFFIC ACCIDENTS

- PHD THESIS SUMMARY -

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The PHD thesis comprises:

- A table of contents that totals 3 pages;
- An introduction that totals 3 pages;
- General part structured in 4 chapters totaling 34 pages;
- Personal part structured in 5 chaprers totaling 149 pages;
- 108 figures;
- 87 tables;
- The bibliography of the thesis contains 388 bibliographic references and totals 15 pages;

Note: This abstract summarizes the content and the selective bibliography of the thesis.

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MOTIVATION AND OBJECTIVES OF THE DOCTORAL STUDY

Transport has been a key factor in the economy since ancient times. However, there is a constant contradiction between society, which calls for more mobility, and public opinion, which has become increasingly intolerant to the poor quality of transport services. The transport system needs optimization so as to meet the demand for sustainable development, both economically and socially, but also from the environmental point of view (1).

Based on the data provided by each EU country, it is estimated that 135,000 people are seriously injured, consequentionally there are, on average, 5 serious injuries per death (2). In Romania, according to the statistics of the Romanian Road Police Directorate, following a decreasing trend between 2012-2014, 9380 road accidents occurred in 2015, resulting in 1893 deaths and 9056 serious injuries (3).

Even though they rarely cause death, due to the associated vascular injuries or embolic complications, the importance of a thorough study of osteo-articular injuries is due to their relatively high frequency and the fact that they produce important disabilities (4). As a result of road accidents, all types of osteo-articular injuries can occur, from simple sprains, to full dislocations and open cominus fractures (5).

The scope of the study was to make a comprehensive analysis of osteo-articular injuries produced in road traffic accidents. To achieve this goal, the doctoral research was divided into 3 research paths, each with well-established objectives.

STUDY 1 – ANALYSIS OF THE DYNAMICS OF ROAD TRAFFIC ACCIDENTS AND OF THE FACTORS INFLUENCING THE GRAVITY OF OSTEO-ARTICULAR INJURIES

Introduction

Road traffic accidents are responsible for both a substantial number of deaths and injuries, as well as the loss of healthy years of life, generally more than most human diseases (6). Road traffic accidents result from a combination of factors linked to the components of the road system, the environment, vehicles and their users, and how they interact (7). Global efforts to reduce the number of road accidents and, therefore, injuries were facilitated by conducting studies that analyzed accident dynamics, injury patterns, risk factors, etc. (8, 9).

Material and method

The objectives of the present study were to analyze the dynamics of road traffic accidents resulting in osteo-articular injuries during the studied period, to analyze the risk factors in road traffic accidents, to identify the pattern of osteo-articular injuries produced in road traffic accidents and to identify factors that can influence the production and severity of osteo-articular injuries.

In order to meet the above mentioned objectives, a retrospective quantitative study was carried out, collecting data from 2012-2015. Statistical processing was performed using the SPSS v 20 and GraphPad Prism v6 programs. The threshold of statistical significance was a priori set at 0.05. The charts were made using SPSS v20, GraphPad v6 and Microsoft Excel. The data is expressed in numeric or as a percentage of the whole.

Results

Following the collection of data on osteo-articular injuries produced by road traffic accidents, 676 cases were identified, out of which 446 cases of osteo-articular injuries were produced in accidents in which the road user survived and 230 cases with osteo-articular injuries in fatal accidents.

Of the total of 676 cases included in this study, 34.90% were between the ages of 41 and 65, 58% were males, most of them were living in urban areas, most accidents occurred in 2015, in September, in the 13:00-18:00 hour range, on the streets of urban areas. 20% of the accidents occurred during rain, 12% on snow, 5% in glazed frost conditions and 3% in fog conditions. In 19% of cases, traces of alcohol were found in the blood, in 39% of the cases the forensic experts did not find any signs of braking on the spot. Most accidents occurred at a speed of 40 [km / h] due to pedestrians crossing the street in places where this is not permitted. Pedestrians forn the majority of injured. In 58% of cases, the injured had multiple osteo-articular injuries, in 69,10% of cases the inferior limbs were affected. 89.9% of the injuries were fractures, 48% were complex, closed with the preservation of the integrity of the skin 84%, at the level of the diaphysis of both calf bones, severity AIS II (*Abbreviated Injury Score*) în 59,80% of cases. The most common production mechanism was in the form of impact followed by projection, with a percentage of 29%. Out of the total of 446 victims who survived the accident, most (34.08%) were hospitalized between 1 week and 2 weeks. Given the time of death from road traffic accidents, out of the 230 cases, 48.26% died at the scene.

Statistical analysis of factors influencing the seriousness of road accidents in which osteo-articular injuries occurred revealed statistically significant correlations ($p < 0.0001$) with: age, sex, background, month of the accident, place of the accident, existence of braking, speed at the time of the accident, alcohol comsumption, violation of traffic rules, existence of protective mechanisms, the difficulty in extracting the victim, type of injured, existence of multiple injuries, AIS, the production mechanism, type of injury, injury according to the analyzed segment, complexity of the injury and the closed / open character of the wound.

The probability of death increases with age, it is higher for men and for those from rural areas, the death rate is higher outside the locality on national and European roads and in the locality on county roads, a higher rate has also been found and in cases where there was no braking, in the case of alcohol consumption and in the absence of protection mechanisms. The incidence of fatal accidents increases with increasing speed, higher probability of death in pedestrians, multiple injuries, in the case production mechanisms such as hit followed by tilting and projection and in the event of a hit followed by fall and trampling; also, the probability of death increases directly in proportion to the severity and complexity of the injuries.

The statistical analysis of factors influencing the severity of osteo-articular injuries produced in road accidents, quantified by the AIS score, revealed statistically significant correlations with: the fatal/non-fatal character of the accident, sex, background, the place of the accident, the speed at the time of the accident, the violation of traffic rules, the difficulty of extracting the victim, the existence of multiple injuries and the mechanism of production.

The majority of AIS I - AIS IV injuries are predominant in males and those from rural areas, the severity of injury increases with increasing speed, most of AIS II, AIS III and AIS IV injuries were caused by pedestrian crossings through unauthorized locations, the need for extrication and the existence of multiple injuries is directly proportional to the severity of the osteo-articular injuries, the AIS V injuries also occurred due to the lack of adaptation to traffic conditions at speeds of 90 [km / h] by frontal impact, lateral impact left or rolling of the vehicle.

To establish the pattern of osteo-articular injuries, a statistical analysis of the injuries was made according to the type and the segment injured by crustabulation with the type of injury and the production mechanism. Following the analysis, statistically significant correlations were discovered between injuries and the production mechanism for pedestrians and motorists. As far as other road users are concerned, because of the small number of cases and the lesion diversity, the crosstabulation did not yield statistically significant results, but in order to have an overview of the lesion pattern, their results were introduced in this study.

In the case of the pedestrian impact mechanism, the most common fractures in the bones of the calf; in the case of fall and trampling, most commonly malleolus fractures were produced; in the event of a hit followed by a fall, the most common fractures were occurring at the level of the proximal epiphyses of the calf bone or malleolus fractures; in the case of the impact mechanism followed by projection, the most frequently produced fractures occurred in the diaphysis of the calf bone, followed by fractures of the pelvic ring; n the case of the impact mechanism followed by tilting and projection, most commonly fractures of the pelvic ring have occurred; the same thing could be noticed in the complex mechanism of impact followed by the fall and then the trampling.

In the case of the front impact mechanism, the driver most frequently suffered fractures in the femur and in the acetabulum; in the case of a right lateral impact, the driver of the vehicle suffered a punch or elbow dislocation; in the case of left side impact, the driver most frequently suffered fractures in the distal epiphyses of the forearm bone.

In order to determine this relationship between the speed at the moment of impact, the type of injured person and the characteristics of the osteo-articular injuries produced in the road traffic accident, a statistical analysis of the injuries was made according to the severity of the accident, the existence of multiple injuries, the existence of open injuries, the complexity of the injury, the type and severity of the injury as quantified by AIS, by crosstabulating with the type of traffic participant and the speed at the moment of impact. Following the analysis, statistically significant correlations were found between lesion characteristics and speed for pedestrians and vehicle drivers.

For pedestrians, death does not occur at speeds of less than 40 [km / h], and the number of deaths increases directly in proportion to the speed, with speeds equal to or greater than 80 [km / h], all accidents ending with death, and in motor vehicle drivers, death does not occur at speeds of less than 60 [km / h], and at speeds greater than or equal to 100 [km / h] the death rate is 100%. Also, drivers did not have injuries when the impact speed was less than 30 [km / h]. With regard to the complexity of the osteo-articular lesion, for both pedestrians and motorists, complex injuries have occurred at speeds of over 30 [km / h], with simple injuries being excluded at speeds above 50 [km / h / h] for pedestrians and 100 [km / h] for the drivers of the vehicles.

In order to determine this relationship between speed at the moment of impact, the mechanism of production and the characteristics of osteo-articular injuries produced in the road accident, a statistical analysis of the injuries was made according to the severity of the accident, the existence of multiple injuries, the existence of open injuries, the complexity of the injury, the type of lesion and its severity quantified by AIS, using crosstabulation with the production mechanism and the speed at the moment of impact. Following statistical analysis, statistically significant correlations were found between lesion characteristics and speed for simple impact mechanisms, impact followed by trampling, impact followed by projection, front impact and rolling mechanism.

For pedestrians, the mechanism of impact followed by projection has produced injuries starting with speeds higher than 30 [km/h], death occuring at speeds higher than 40 [km/h] and simple injuries occured up to speeds below 80 [km/h]. For the car drivers, the frontal impact mechanism between two cars produced injuries starting at speeds above 40 [km / h], with death at speeds of more than 60 [km / h], and simple injuries produced up to speeds below 90 [km / h].

Discussions

The results of this study correlated with the results from specialty literature. Minca et al. (10) showed that the vast majority of motor vehicle drivers involved were men (89.2%), but passengers and pedestrians were almost gender-balanced. Concerning accident sites, it is specified in specialty literature that several different risk factors can contribute to road deaths in rural areas: drivers in rural areas are more likely to fail to take safety measures, such as the use of seat belts (11) or driving at higher speeds (12); public roads may be less secure than urban roads (11). It has been demonstrated that the use of seat belts significantly reduces the death rate (13). The risk of being fatally injured is reduced by 40-50% for drivers and front passengers (14). Several studies have shown that the risk of fatality increases rapidly with alcoholism (15, 16). Archana et al. (17) found that pedestrians represented the maximum number of deaths (35.79%) followed by users of 2-wheeled motor vehicles (motorcycles, scooters, etc.) (30.5%). Algora-Buenafé (18) noted that with regard to the traffic accident typology that caused death, frontal collisions were 28.5% and the collisions of vehicles with pedestrians were 22.6%. Hou et al. (19) found that fractures of the lower limbs are the most common, followed by fractures of the upper extremity, the skull and the maxillofacial region.

The correlation between speed and accident / accident resulting casualties was described by power functions (20, 21). Even small changes in average speed have a particular effect on the severity of the accident and hence the risk of injury. An average speed increase of 1 [km / h] is associated with a 3% higher risk of injuries involving harm and a 5% higher risk of suffering serious or fatal harm [20]. The study by Leaf and Preusser (22) showed that the proportion of fatal accidents that occurred at speeds below 40 [km / h] was 10% and less than 1% at speeds of less than 32 [km / h]. Nilsson (20) and then Elvik (23) have shown that lower average speeds in response to speed limits reduce the likelihood of casualties.

Conclusions

1. The results of this study could be useful not only for forensic experts but also for vehicle safety researchers.
2. Awareness of the characteristics of accidents and risk factors will improve vigilance for certain types of osteo-articular injuries suffered by road users, stimulate the development of diagnosis-targeted strategies, and will therefore contribute to better outcomes for the patient with osteo-articular injuries.
3. It is very important to accept that osteo-articular injuries caused by road traffic accidents are not the result of random and uncontrolled factors. The injuries can be prevented, and the responsibilities of public health workers are: collecting data, identifying risk factors, making interventions and implementing proven prevention methods.
4. Knowing the factors that influence the severity of the accident and the severity of osteo-articular injuries could help those responsible for road safety, implement strict traffic rules, rank hazards in the susceptible population, and educate them.
5. Identifying the lesion pattern can help early recognition and prompt treatment of injuries caused by road accidents, which is essential for obtaining the best therapeutic results. However, the most significant impact on reducing the burden of osteo-articular injuries caused by traffic accidents will come from prevention programs.
6. There is a strong statistical relationship between speed and road safety. When the average speed in traffic is low, the number of accidents and the severity of injuries will almost always decrease. When the average traffic speed increases, usually the number of accidents and the severity

of injuries will increase. The relationship between speed and road safety is causal and can be explained by the basic laws of physics and biomechanics.

STUDY 2 – ANALYSIS OF THE COMPLICATIONS OF OSTE-ARTICULAR INJURIES PRODUCED IN ROAD TRAFFIC ACCIDENTS

Introduction

Every year, more than 1.2 million people die and around 20-50 million are injured worldwide due to road traffic accidents (24). Romania, as well as other developed countries, compared to 2000, shows a decreasing trend in the number of fatal accidents, but in contrast, the number of accidents that result only in non-fatal bodily injuries shows a tendency for growth (25).

In the prevention of injuries caused by road accidents, given that the number of injured persons is much higher than the number of deceased persons, it is important to analyze these injuries. A significant problem, when research focuses on non-fatal accident information, is that there is a poor correlation between the immediate assessment of the severity of a lesion and the long-term consequences, and here we refer to complications and their outcome, which is translated into disabilities (26).

Material and method

The objectives of the present study were to present the profile of people with complicated osteo-articular injuries produced during road traffic accidents, to present the factors that influence the occurrence of complications of osteo-articular injuries and to identify the factors influencing their severity.

In order to meet the above objectives, a retrospective quantitative study was carried out, collecting data from 2013-2016. Statistical processing was performed using the SPSS v 20 and GraphPad Prism v6 programs. The threshold of statistical significance was a priori set at 0.05. The charts were made using SPSS v 20, GraphPad v6 and Microsoft Excel. The data is expressed in numeric or as a percentage of the whole.

Results

The statistical analysis of factors correlated with the occurrence of complications of osteo-articular injuries produced in road traffic accidents revealed statistically significant correlations with: age, background, AIS, pre-existing pathologies, impact velocity, difficulty in extracting the victim and type of injured road user (Table 1).

Table 1 Factors that influence complications

		With complications	**Without complications**
Age	0-14	0.0%	100.0%
	15-24	18.1%	81.9%
	25-40	23.6%	76.4%
	41-65	**29.0%**	**71.0%**
	>65	15.2%	84.8%
Background	Urban	**26.5%**	**73.5%**
	Rural	13.7%	86.3%
AIS	AIS I	8.7%	91.3%
	AIS II	14.3%	85.7%
	AIS III	40.2%	59.8%
	AIS IV	83.3%	16.7%
	AIS V	**100.0%**	**0.0%**
Pre-existing pathologies (PP)	Obesity	**92.0%**	**8.0%**
	Osteoporosis	71.4%	28.6%
	Diabetes	66.7%	33.3%
	Arterial hypertension	33.3%	66.7%
	Multiple PP	33.3%	66.7%
	No PP	11.9%	88.1%
Speed	<30 [km/h]	12.5%	87.5%
	30 [km/h]	13.5%	86.5%
	40[km/h]	9.8%	90.2%
	50 [km/h]	20.0%	80.0%
	60 [km/h]	25.9%	74.1%
	70 [km/h]	25.0%	75.0%
	80[km/h]	39.3%	60.7%
	90 [km/h]	91.7%	8.3%
	100 [km/h]	**100.0%**	**0.0%**

	>100 [km/h]	**100.0%**	**0.0%**
Difficulty of extracting the vicim (DEV)	Yes	**48.8%**	**51.2%**
	No	17.9%	82.1%
Type of road user	Pedestrian	13.1%	86.9%
	Autovehicle passenger	**33.6%**	**66.4%**
	Wagon passenger	11.1%	88.9%
	Motorcyclist	**31.0%**	**69.0%**
	Cyclist	9.5%	90.5%

Factors that correlate with the severity of the complications are related to the physiological and pathological factors of the victims (age, background, AIS, pre-existing pathologies, affected anatomical region, injury complexity and closed / open injury) and road traffic accident dynamics (impact speed, difficulty in extracting the victim).

To study the severity of complications of osteo-articular injuries produced in road accidents, the present study analyzed the adaptive disability caused by these, depending on the anatomical region affected by osteo-articular injuries and their severity quantified by AIS, the relationship between them being presented in Table 2 and Table 3.

Table 2 Corelation between adaptive incapacity (AI) and anatomical region (AR)

		0-19%	**20-49%**	**50-69%**	**70-89%**	**NO AI**
Shoulder	No. of cases	1	2	2	0	28
	% of AR	3%	**6,1%**	**6,1%**	0%	84,8 %
Arm	No. of cases	0	9	0	0	35
	% of AR	0%	**20,5%**	0%	0%	79,5 %
Elbow	No. of cases	0	1	0	0	4

	% of AR	0%	**20%**	0%	0%	80%
Forearm	No. of cases	2	1	1	1	50
	% of AR	**3,6%**	1,8%	1,8%	1,8%	90,9 %
Fist	No. of cases	2	1	1	0	4
	% of AR	**25%**	12,5%	12,5%	0%	50%
Basin	No. of cases	0	5	6	2	47
	% of AR	0%	8,3%	**10%**	3,3%	78,3 %
Thigh	No. of cases	0	9	6	3	40
	% of AR	0%	**15,5%**	10,3%	**5,2%**	69%
Knee	No. of cases	0	2	3	1	22
	% of AR	0%	7,1%	**10,7%**	3,6%	78,6 %
Calf	No. of cases	0	7	9	4	88
	% of AR	0%	6,5%	**8,3%**	3,7%	81,5 %
Ankle	No. of cases	0	8	3	1	35
	% of AR	0%	**17%**	6,4%	2,1%	74,5 %

Table 3 Corelation between adaptive incapacity (AI) and AIS

		0-19%	**20-49%**	**50-69%**	**70-89%**	**NO AI**
AIS I	No. of cases	2	2	0	0	42
	% of AIS	**4,3 %**	**4,3%**	0%	0%	91,3%
AIS II	No. of cases	3	23	15	1	252
	% of AIS	1%	**7,8%**	5,1%	0,3%	85,7%
AIS III	No. of cases	0	18	10	11	58
	% of AIS	0%	**18,6%**	10,3%	11,3%	59,8%
AIS IV	No. of cases	0	2	3	0	1
	% of AIS	0%	33,3%	**50%**	0%	16,7%
AIS V	No. of cases	0	0	3	0	0
	% of AIS	0%	0%	**100%**	0%	0%

Discussions

The present study showed that the rate of complications of osteo-articular injuries increases directly proportional to age, with a peak in age group 41-65. This can be explained by the fact that with aging, bone tissue undergoes changes that lead to both the increase in the frequency of injuries and the slowing down of healing mechanisms. Similar results had Braver and Trempel in 2004, Augenstein et al. in 2005, Li et al. in 2003 (27, 28, 29). Tingvall et al. and Bohman et al. declared that even if the risk of injuries that lead to complications was low for the AIS I type injuries, these types of injuries are very common, thus representing the majority of injuries that lead to complications.

Regarding the link between pre-existing pathologies and the rate of complications, Tarantino et al. concluded that qualitative and quantitative alterations of osteoporosis explain the progressive deterioration of the bone's ability to heal, increasing the risk of complications (30). Reffering to the type of injured person, Milroy and Clark drew attention to passenger injuries in vehicles and noted a correlation between the type of injury and the rate of complications similar to that of the present study (31).

Conclusions

1. This study identified the factors that influence the occurrence and severity of late complications of osteo-articular injuries caused by road traffic accidents.
2. It is important to know and understand these factors, both to improve the knowledge regarding the variations of the injuring mechanism and also to identify the highest priorities for the development of countermeasures to reduce the rate of complications.
3. Also, the severity of complications will remain an important field for assessing the socio-economic impact of trauma in the future.

STUDY 3 – COMPUTERIZED SIMULATIONS OF PELVIC TRAUMA PRODUCED IN ROAD TRAFFIC ACCIDENTS

Introduction

In the musculoskeletal system, the pelvis is one of the most vital components. From the biomechanical point of view, basic load transmission and stress distribution under physiological loading conditions show that much of the load is transferred through the compact bone tissue and the main pelvic support areas are the sacro-iliac joint and the pubic symphysis, which lead to the primary load transfer surfaces to be located in the upper acetabular margin (32, 33). Because of its architectural form and structure, pelvic bone mechanics are also complex (34).

In order to establish the biomechanical response and trauma tolerance, the conditions of road traffic accidents were simulated by experimental analysis (35, 36, 37). Through these investigations, different criteria for fracture tolerance have been established with the help of different test protocols. Finite Element Model (FEM) has often been used to investigate various aspects of orthopedics (38, 39, 40).

Material and method

The objectives of the present study were to develop a model of the three-dimensional finite elements of the pelvis to perform computerized simulations of the mechanisms for producing pelvis fractures in road traffic accidents with the ultimate goal of better understanding the mechanical response of the pelvis during loads produced at the time of the accident.

The accomplishment of this goal was achieved in several steps, initially a CT scan of the pelvis was made, then the CT scan images in the "Dicom" format were processed using the "Amira" software to create a three-dimensional model of the pelvis of the patient, which was then processed with the software "ICEM Surf" and the model of the three-dimensional finite elements (FE) of the pelvis was made. Furthermore, the three-dimensional FE pelvis model was imported into the "Autodesk Inventor Professional" software, where the material properties of the pelvis were introduced, and simulation of fracture scenarios was done taking into account impact loads.

Results

Scenario I – anterior impact at the pubic level-pedestrian

In terms of this scenario, the fracture occurs at a load of 1500 [N], the maximum tension reaching 143,543 [MPa], the bone moving by 0,678266 [mm] (Figure 1).

Scenario II – lateral impact at the ilium level- pedestrian

In terms of this scenario, the fracture occurs at a load of 7,500 [N], the maximum tension reaching 150,78 [MPa], the bone moving by 3,20085 [mm] (Figure 2).

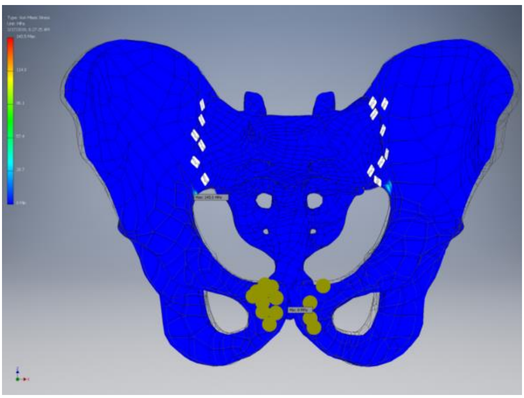

Figure 1 Scenario I – maximal tension according to the von-Mises criterion

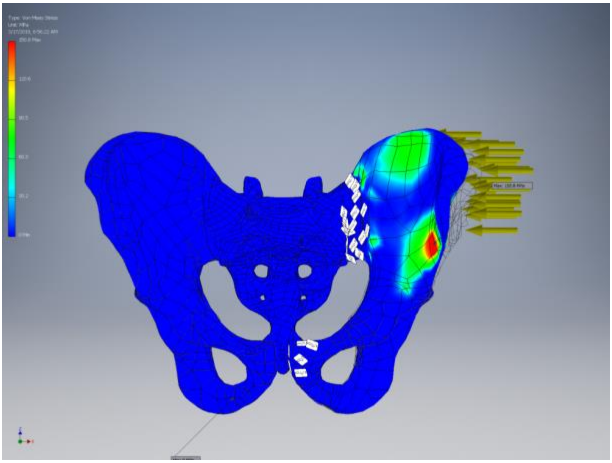

Figure 2 Scenario II – maximal tension according to the von-Mises criterion

Scenario III – posterior at the ischium level-pedestrian

In terms of this scenario, the fracture occurs at a load of 6000 [N], the maximum tension reaching 165,249 [MPa], the bone moving by 0,676843 [mm] (Figure 3).

Figure 3 Scenario III – maximal tension according to the von-Mises criterion

Scenario IV – antero-posterior trampling of the pelvis-pedestrian

In terms of this scenario, the fracture occurs at a load of 4000 [N], the maximum voltage reaching 156,873 [MPa], the bone moving by 0,908495 [mm] (Figure 4).

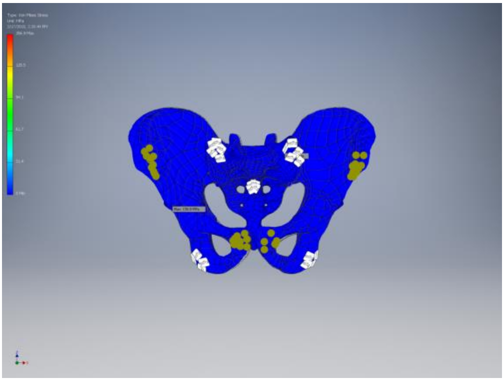

Figure 4 Scenario IV – maximal tension according to the von-Mises criterion

Scenario V – postero-anterior trampling of the pelvis- pedestrian

In terms of this scenario, the fracture occurs at a load of 8000 [N], the maximum tension reaching 144,214 [MPa], the bone moving by 3,16211 [mm] (Figure 5)..

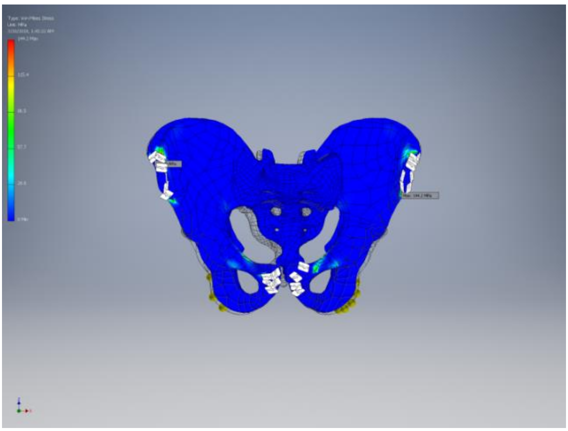

Figure 5 Scenario V – maximal tension according to the von-Mises criterion

Scenario VI – frontal impact- driver

In terms of this scenario, the fracture occurs at a load of 4000 [N], the maximum tension reaching 144,489 [MPa], the bone moving by 0,425204 [mm] (Figure 6).

Scenario VII – lateral left impact- driver

In terms of this scenario, the fracture occurs at a load of 7500 [N], the maximum tension reaching 144,408 [MPa], the bone moving by 3,24643 [mm] (Figure 7).

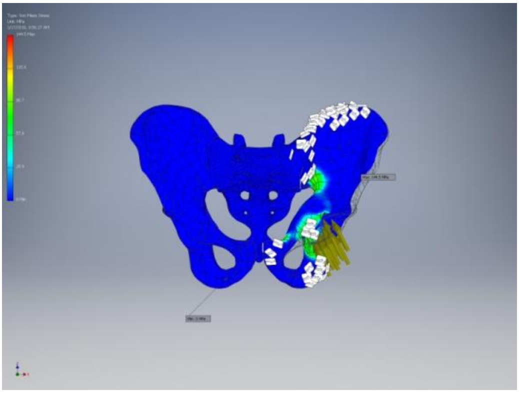

Figure 6 Scenario VI – maximal tension according to the von-Mises criterion

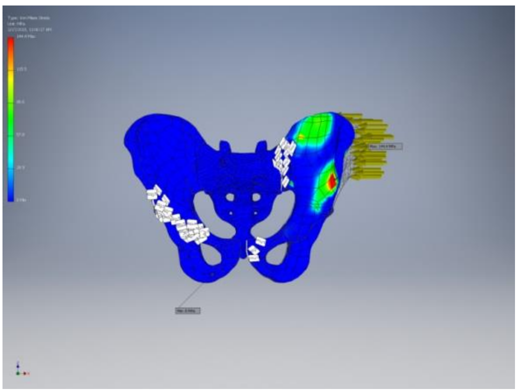

Figure 7 Scenario VII – maximal tension according to the von-Mises criterion

Discussions

Early models of the pelvis were either simplified 2D (41, 42, 43) or aximetric models (44, 45). Most three-dimensional FE models (34, 46, 47) used simplified pelvic geometry, average properties of materials and / or did not validate FE stress and tension predictions. The work of Dalstra et al. was the first attempt to develop and validate a three-dimensional FE model of the basin using subject-specific geometry and material properties (34).

In the studies of Daniel Kluess et al. (48) and Santanu Majumder et al. (40, 49), the model materials were determined by the gray value of the CT scan data but did not contain the pelvic ligaments. Daniel Kluess et al. (48) have just established and validated a non-sacrum FE semi-pelvis model. In the study of Anderson et al. (50), it was found that the FE model became significantly stronger when it was assumed that the cortical bone thickness and Young's spongy bone module were constant.

In the present study, the maximum tension according to von Mises and the maximum deformation were the experimental variables for validation of the finite element model of the pelvis. Previous studies have used the stress / deformation ratio, the von Mises criterion, the main tensions in the force application plans, the tension components in the tension directions (39, 50, 51). Both the main tension in plane at Anderson et al. (39) and tension components in the tension directions of Leung et al. (51) were local variables for FE model validation. Differences in boundary conditions, material properties and applied load make it impossible to compare FE stress and tension predictions from this study with previous studies. However, the findings show that the FE model developed in this study produces a stress field similar to that reported in the previous literature and that could meet our needs (52).

Conclusions

1. The finite element model of the pelvis in this study provides the possibility to analyze and describe the stresses and deformations given by the loads and constraints of different simulation scenarios of the mechanisms of bone injury in road traffic accidents.
2. Following the simulations, both the maximum load that the pelvis can withstand until reaching breaking point, as well as the possible location of the fracture and movement of the bone were identified.
3. It can be considered that the model made is a first step in developing a model of the entire human skeleton that can be used in biomedical engineering, as well as in the analysis of the safety road users. Such a

model should, however, be adjusted and further validated, depending on the research objectives and the specific characteristics of each subject.

4. These findings also reinforce the need for primary prevention, which in turn must be based on a comprehensive understanding of the biomechanics of osteo-articular injuries.

FINAL CONCLUSIONS

1. This study has shown that osteo-articular injuries from road traffic accidents in the northeastern region of Romania represent a major social, economic and public health problem.
2. This thesis has conducted a comprehensive analysis of osteo-articular injuries produced in road traffic accidents, providing information on:
    a. the epidemiology of road traffic accidents, with creating the victim's profile and the pattern of osteo-articular injuries;
    b. identifying the factors that influence the severity of accidents and the severity of osteo-articular injuries produced within them;
    c. deeper study of the relationship between speed and injury characteristics, identification of cases;
    d. the late effects of osteo-articular injuries caused by road traffic accidents; cases that led to the late osteo-articular complications with the identification of the risk factors for their appearance and severity were analyzed;
    e. the biomechanics of road traffic accidents in which osteo-articular injuries have occurred, focusing on the pelvis, a bone formation often injured in road accidents, developing a model of the three-dimensional finite elements of the pelvis, with which a series of computerized simulations of the mechanisms for producing pelvis fractures in road traffic accidents were carried on.
3. In order to reduce the seriousness of road accidents and their consequences, the punitive measures need to be complemented by education and information measures for the population, which may consist of education programs in schools or social centers, the involvement of the media and the production of information videos to be broadcasted during audience peak times and outdoor information

campaigns with distribution of leaflets containing brief information on improving road traffic.

4. Road accidents are predictable and can therefore be prevented. As a way to fight the difficulties, there must be close coordination and collaboration with use of holistic and integrated methods, involving several sectors and disciplines. Although there are many interventions that could save lives and reduce the number of osteo-articular injuries, political will and dedication are essential and without them there can be no results. Strict application of traffic rules and strict punishment will not solve the persistent crisis. Drivers should learn to consider and respect the other drivers of the vehicles and pedestrians in traffic so that our roads become safer.

ORIGINALITY AND RESEARCH PERSPECTIVES

Road traffic accidents are a topic issue because of the severe socio-economic impact on contemporary society, as evidenced by increased mortality and the production of major incapacity. Some of the most common injuries due to road accidents are osteo-articular injuries. Even if they rarely cause death, they cause major disabilities.

The results of this study have shown the need to extend research into road traffic accidents:

1. Establishing a computerized road traffic accidents registry at national level to record the risk factors, circumstances and chain of events leading to accidents.
2. Expanding this study nationwide and turning it into a multicenter one in order to increase the database, to verify and reinforce the results of the study and to compare the results from different regions of the country.
3. Expanding this study to include head, face, vertebral, thoracic and abdominal trauma.
4. Deepening the analysis of the identified risk factors by correlating them in order to be able to see their cumulative effect on the dynamics of road traffic accidents and, implicitly, the injuries produced within them.
5. Developing a risk scale for each type of injury based on impact the speed by further studying the relationship between speed and injuries caused by road traffic accidents, using a larger number of cases and collecting the exact speed at the moment of impact.

6. Identifying the injury pattern in other traffic participants by increasing the study lot, and collecting particular data about these road users.
7. Developing a risk scale for the severity of osteo-articular complications, starting from the factors identified in this study, increasing the study batch by increasing the study period and expanding to a multicenter study.
8. Developing a model of the entire human skeleton that can be used in biomedical engineering as well as safety analysis of road users.

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