VIRTOPSY: EXPERT OPINION BASED ON 3D SURFACE AND RADIOLOGICAL SCANNING AND DOCUMENTATION IN FORENSIC MEDICINE

Michael Thali[1], Ursula Buck[1,2], Silvio Näther[1]

[1]**University of Bern, Institute of Forensic Medicine,**
Center Forensic Imaging and Virtopsy
Buehlstasse 20
3012 Bern
Switzerland
Telephone: +41 31 631 84 12
Fax: +41 31 631 84 15
email: ursula.buck@irm.unibe.ch
[2]**Canton police Bern, technical accident service**, Schermenweg 9, 3001 Bern, Switzerland

ABSTRACT

Apart from forensic medical examinations (external examination and autopsy), three-dimensional technologies and high-tech methods are gaining more and more importance in accident and crime investigations. Radiological imaging and 3D surface scanning deliver highly precise 3D data of accident victims and damaged vehicles. Based on these digital data computer-assisted, drawn-to-scale analysis of the injuries of the body and damages to the vehicle allow for the reconstruction of the course of accident.

In the present work a collision between a car and a cyclist was analyzed with the described methods. The body of the accident victim was scanned with MSCT and 3D optical surface scanning. The accident car and the bicycle were also digitized with the surface scanner. The accident scene was documented by the use of a 3D laser scanner and photogrammetry. With the real data based reconstruction the collision position of the vehicles and the course of the accident could be determined. Furthermore, an external institution used the collected data to estimate the velocity of the car at time of collision.

Keywords: accident reconstructions, photogrammetry, three dimensional, soft tissues, bones

FORENSIC MEDICINE has the task of documenting, analyzing and explaining medical findings, scientifically and understandably, from both the living and the dead, for the judicature.

In 2000 the science project Virtopsy (www.virtopsy.com) triggered a change process in the traditional field of forensic medicine, using 3D technologies in accident and crime investigations. The Virtopsy project was started by the Institute of Forensic Medicine and the Institute of Diagnostic Radiology of the University of Bern, Switzerland, with the hypothesis that non-invasive imaging might predict autopsy findings and maybe give additional information (Thali, 2003).

Today Virtopsy combines radiological imaging methods (MSCT/MRI), 3D optical surface scanning, image assisted post mortem biopsy and post mortem angiography for the forensic examination of deceased persons. Because of the close collaboration with the police, also 3D data of the crime or accident scene can be included in the examination.

An important question in the analysis of the victims of traffic accidents, for example in collisions between motor vehicles and pedestrians or cyclists, is the impact position. Apart from forensic medical examinations (external examination and autopsy), three-dimensional technologies and high-tech methods are gaining more and more importance in accident and crime investigations (Brüschweiler, 1997; Subke 2000; Thali, 2005; Buck 2007).

In the present work a traffic accident case illustrates the results and benefits of a 3D documentation and computer-assisted, drawn-to-scale analysis of the injuries of the body and damages to the vehicle.

MATERIAL AND METHODS

In the following case, an accident between a car and a cyclist was investigated. The cyclist died after a collision with a car. It was initially unclear if the cyclist was hit from behind, driving already on the road, or if he was crashed from the side while crossing the road. It should also be determined what speed the car had at the time of collision.

The internal body of the cyclist was documented with post-mortem MSCT on a 6-row CT scanner (Emotion 6, Siemens, Germany). The surface of the body with all external injuries was documented with the optical 3D digitizing system GOM TRITOP/ATOS. This fringe pattern projection system is based on the principle of triangulation and acquires within seconds highly precise surface data of the scanning object. With the same system, the bicycle and the car were digitized in 3D.

Additional to the 3D data sets of the body, police experts collect 3D data of the accident site with means of photogrammetry and 3D laser scanning.

The analysis included the processing of the obtained data and the generation of 3D models, the determination of the driving direction of the vehicle, the correlation of injuries to the vehicle damages, geometric determination of the impact situation and evaluation of further findings of the accident.

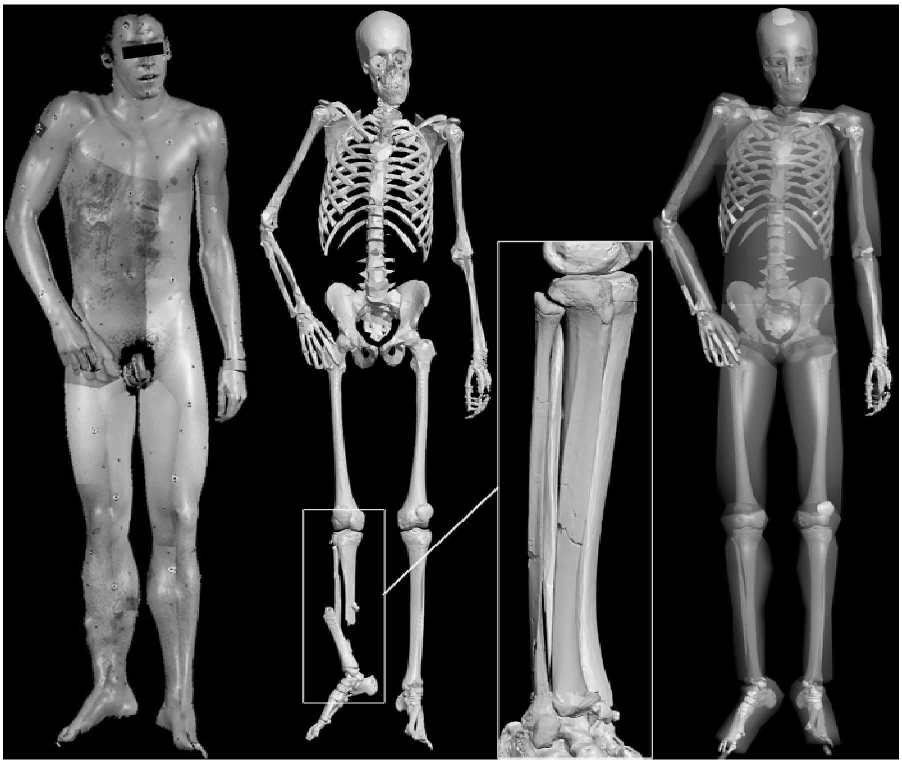

Figure 1: 3D models of the deceased

RESULTS

The radiological examinations deliver 3D data of all internal structures of the body, including injuries to the soft tissue and fractures of the bones. Out of these data 3D models of the osseous system were generated. The 3D optical surface scanning delivers highly precise, drawn-to-scale and true-to-colour surface data of the body and the vehicles (Fig. 1).

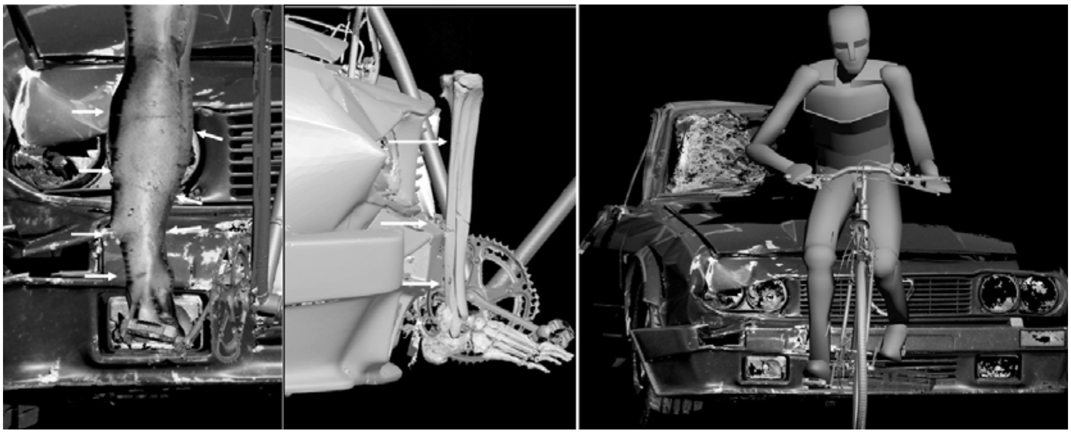

Figure 2: Reconstructed impact position

By computer-assisted 3D comparison of these complex datasets the primary collision position between the car and the cyclist respectively bicycle was determined. The patterned skin injury of the right upper leg, as well as the bone fractures of the tibia and fibula matched to the front structure of the car. The cyclist was struck by the car from behind whilst driving on the right side of the road (Fig. 2). Secondary the bicycle was loaded onto the car (Fig. 3). Thereby, the transfer of the traces from the bicycle to the car was considered. The damage to the bicycle (arrows) matches to the damages of the car.

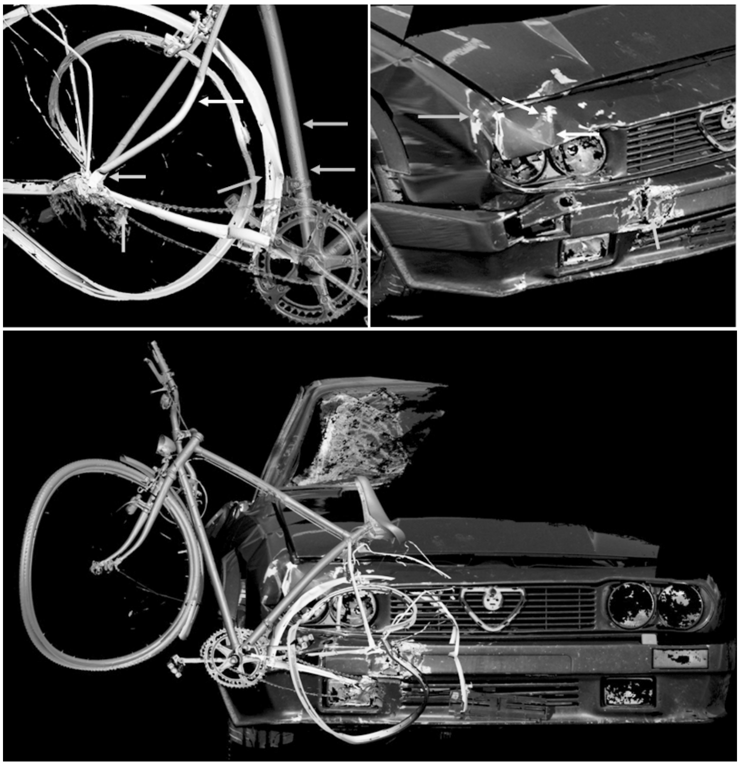

Figure 3: 3D reconstruction how the bicycle was loaded onto the car

DISCUSSION

The present case demonstrates how the described 3D reconstruction methods significantly improve the forensic investigation. The computer-assisted 3D comparison of complex datasets allows for detection and visualisation of forensic relevant findings regarding the course of accident.

The process of 3D data collection is optimised, referring to measurement time and user friendly manipulation of the equipment. The radiological examination and the 3D surface documentation of the victim is performed in the same examination room. The employed GOM ATOS surface scanner is mounted on a robotic arm above the CT-couch. This allows for an automated scanning procedure controlled by a single operator. The GOM system is a flexible high-end and easy-to-use 3D digitizing device. The digitizing system is mobile, so it can also be used outdoors to detect traces on site. Large measurement volumes of up to 1.5 x 1.5 meter and a high power light source in the latest generation of ATOS scanners enable short measurement times.

The illustration of the results in graphic images and legends allows for a better and more objective presentation of the results to a third party than a written protocol. Other experts can check the results at any time.

The acquisition and the electronic storage of the drawn-to-scale, accident-relevant data allow examination of the objects (vehicles, clothes, etc.) at any time using the computer and can be included in future analyses. All data are easily exchanged via DVD between the experts examining the case or anonymously with other research institutions (teleforensics).

Based on the precise impact analysis, and the full-scale 3D models of the deformed vehicles, further physical investigations are improved, for example, in the evaluation of the velocity of the car. Furthermore, it is possible to perform biomechanical simulations with these precise data and the detected contact points between the body and the vehicle.

This new methods enable an efficient collaboration of forensic medicine and police. Experts from both authorities can be involved in the analysis and the reconstruction on the computer. The body of the traffic accident victims can be brought virtually in the accident scene, and enables a whole reconstruction of the accident to get added values. High costs for the equipment (CT, MRI, Surface scanner) and large amounts of data, which lead to the necessity of high-end computers, special software of course large storage media are still problems that have to be considered, when starting to apply the described methods.

CONCLUSION

Real data based 3D reconstruction, by bringing the body into the virtual 3D accident scene, allows for the delivery of information on accident courses, which were not possible conventionally. The true forensic milestone is the introduction of three dimensional documentation, analysis and reconstruction. This is path-breaking for accident analyses in the future.

References

Brogdon BG, Forensic radiology. 1 th ed. Boca Raton, Florida:CRC PressLLC, 1998.

Brueschweiler W, Braun M, Fuchser HJ, Dirnhofer R, Photogrammetrische Auswertung von Haut- und Weichteilwunden sowie Knochenverletzungen zur Bestimmung des Tatwerkzeuges; grundlegende Aspekte. Rechtsmedizin (1997) 7:1976-83.

Buck U, Naether S, Braun M, Bolliger S, Friederich H, Jackowski C, Aghayev E, Christe A, Vock P, Dirnhofer R, Thali M, Application of 3D Documentation and Geometric Reconstruction Methods in Traffic Accident Analysis: With High Resolution Surface Scanning, Radiological MSCT/MRI Scanning and Real Data Based Animation, Forensic Sci. Int. (2007) 170: 20-28

Subke J, Wehner HD, Wehner F, Szczepaniak S, Streifenlichttopometrie (SLT): A new method for the three-dimensional photoralistic forensic documentation in colour. Forensic Sci. Int. 113 (2000) 289-295.

Thali MJ, Braun M, Buck U, Aghayev E, Jackowski C, Vock P, Sonnenschein M, Dirnhofer D, VIRTOPSY – Scientific Documentation, Reconstruction and Animation in Forensic: Individual and Real 3D Data Based Geo-Metric Approach including Optical Body / Object Surface and Radiological CT / MRI Scanning. J Forensic Sci 50(2) (2005) 428-424.

Thali MJ, Yen J, Schweitzer W, Vock P, Boesch C, Ozdoba C, Schroth G, Ith M, Sonnenschein M, Doernhofer T, Scheurer E, Plattner T, Dirnhofer R, Virtopsy, a New Imaging Horizon in Forensic Pathology: Virtual Autopsy by Postmortem Multislice Computed Tomography (MSCT) and Magnetic Resonance Imaging (MRI) - a Feasibility Study. J Forensic Sci (2003) 48(2):386-403