FORENSIGRAPHY: THE INTEGRATION OF IMAGING TECHNIQUES INTO THE CRIMINAL JUSTICE SYSTEM

Reingard Riener-Hofer
Ludwig Boltzmann Institute for Clinical Forensic Imaging, Graz
Austria

Bridgette Webb
Ludwig Boltzmann Institute for Clinical Forensic Imaging, Graz
Austria

Eva Scheurer
Institute of Forensic Medicine, Medical University Graz
Austria

Keywords: clinical forensic medicine; forensics; medical imaging; criminalistics; Austria.

Abstract: this article defines imaging in the context of the criminal justice system, introduces the term 'forensigraphy' and presents relevant examples. Legal requirements for the implementation of forensigraphy are discussed.

INTRODUCTION

Through a combination of clinical forensic casework and research since 2008, a platform for exchanging medical, scientific and legal knowledge has been established at the Ludwig Boltzmann Institute for Clinical Forensic Imaging (LBI-CFI). The present overview presents a compilation of the essential elements of forensigraphy (Riener-Hofer, 2013), a promising tool in the investigation of physical assault, domestic violence and motor vehicle accidents, as well as the necessary considerations for its integration into judicial proceedings. Due to the interdisciplinary and emerging nature of this field, knowledge regarding forensigraphy is currently spread across a number of disciplines. Unfortunately, this advantage also acts as a hindrance to those involved in the administration of justice, as they are provided with very few opportunities to gain a succinct yet thorough understanding of the role of imaging in forensic science. By introducing the reader to the applied term 'forensigraphy' and its sub-offerings, the current work disseminates knowledge to key players involved in the evidence-based investigation of violent incidents.

DEFINING IMAGING

Imaging, in the broadest sense, constitutes the visualisation of real objects through the spatial resolution of brightness values and colour (Riener-Hofer, 2013). It allows the preservation of a situation or state of being. The nature of the elements captured varies and may include people, animals and equally items. Advances in technology, as well as the growing number of situations in which objects can be portrayed and immortalised, have given rise to the significant presence of imaging in modern society. On a daily basis, we encounter various applications of imaging techniques, including those used to record or explain situations as well as to visually preserve evidence. This comprehensive definition of imaging includes a variety of techniques ranging from modern imaging procedures such as those used in medicine, to photography, which has existed since the middle of the 19th century (Dirnhofer, Schick, & Ranner, 2010; Schwegler, 2004).

IMAGING IN MEDICINE

The term medical imaging refers to the specific application of imaging procedures in a medical context. In this context, imaging is considered a term which brings together various technical examination methods to provide 2D or 3D imaging data of organs and structures within the human body. Most notably, it is of particular relevance in diagnostic medicine where it is used to diagnose abnormalities due to illness (Levin, 2012). Specifically included here are high-resolution imaging procedures which map biochemical processes, including techniques ranging from conventional diagnostic radiology (native images, contrast agent enhanced images and conventional tomography) to modern imaging procedures such as ultrasound, computed tomography (CT), magnetic resonance imaging (MRI), scintigraphy, subtraction angiography, endoscopy and optical photogrammetric supported 3D scanning (Lexikon-Redaktion, 1999; Püschel, 2007). With the help of these medical apparatuses, the internal structure of the human body can be visually registered, and precisely examined both immediately and in the future.

IMAGING IN THE INVESTIGATION OF CRIMINAL AFFAIRS (FORENSIGRAPHY)

Best defined by returning to the initial comprehensive definition of imaging, forensigraphy incorporates elements of both photography and medical imaging, to visually represent the properties of 'real objects'. However, in contrast to the general definition, forensigraphy is most arguably restricted by the specific character of the 'what' which it portrays. The term forensigraphy broadly encompasses all imaging techniques used to visualise information directly or indirectly associated with criminal affairs. This includes all imaging material which assists in the examination and analysis of criminal activity or which serves law enforcement purposes. Hence, this term can be applied to recordings of people (e.g. suspect mug shots, photographs of murder victims ante- and post-mortem), imaging techniques applied in the analysis of evidence, video recordings (e.g. surveillance cameras), X-ray scanned items (e.g. luggage) and also finally to forensic radiology. Imaging supported forensic biometry (or perhaps rather imaging-supported 'forensimetry') is also attributed to the domain of forensigraphy (Willersinn, 2011).

CLASSIFICATION OF FORENSIGRAPHY

Due to its interdisciplinary nature, forensigraphy finds itself spread across a number of scientific domains. In the following section, its classification will be examined and elaborated upon.

CRIMINAL SCIENCES

According to Schwind (2011), one should differentiate between judicial and non-judicial criminal sciences. Normative penology, extending only as far as the penal provisions themselves, as well as the study of criminal procedural law, which determines the playing rules for a legitimate and orderly criminal procedure, both belong in the first category. The second category, non-judicial criminal sciences, includes criminology and forensic science. Criminology, differentiated from penology due to its status as an empirical science, is considered an independent interdisciplinary sister-science of penal law. It represents an interdisciplinary research branch and examines the manifestations and causes of criminal activities through research in the fields of victimology, penology, criminal rehabilitation, forensic psychology and psychiatry, as well as criminal statistics (Schwind, 2011). In contrast to criminology, which positions the causes of criminal behaviour as the primary pillar in its research, the forensic scientist is mainly concerned with the resolution of a given offence, namely the detection of the crime followed by the apprehension and conviction of the perpetrator(s) (Schwind, 2011).

In order to be able to accurately classify forensigraphy within the system of criminal sciences, a closer examination of the field of forensic science and its sub-offerings is needed. Sub-offerings in this field include crime policy, anti-crime strategies and most substantially in the present context, criminalistics (Schwind, 2011). Crime policy is responsible for the development of methodological and well-reasoned courses of action to resolve and prevent crimes. Anti-crime strategies, although still involved in and influenced by casework, are more concerned with the totality of policing actions in relation to the objectives of crime policy. The third pillar of forensic science is criminalistics. This sub-offering involves the application of techniques from the

natural sciences to examine and analyse traces and evidence (Schwind, 2011).

CRIMINALISTICS

The term criminalistics corresponds to the scientific domain in which criminal operations are systematically identified, analysed and reconstructed (Siller, *no date*). Forensigraphy represents a sub-domain of criminalistics which, with the assistance of imaging and visualisation techniques, enables criminal activities and their consequences to be examined, analysed and reconstructed. In given cases it may also be possible to identify victims and offenders. From the current discussion, it emerges that the nature of forensigraphy positions it within the domain of criminalistics. In this domain, knowledge and methods from a number of scientific fields including biology, chemistry, physics, mathematics and medicine (Schwind, 2011), under which a differentiation between forensic medicine and forensic psychiatry should be made, are applied. These relevant and fit-for-purpose methods are utilised in cooperation, to mutually support and balance each other. Due to its character as a cross-sectional science, research in the domain of forensigraphy requires a multidisciplinary environment such as the one which has been established in the field of criminalistics.

FORENSIGRAPHY IN PRACTICE: EXAMPLES OF IMAGING IN THE PURSUIT OF CRIMINAL JUSTICE

Under the term forensigraphy, four examples of subcategories are identified and discussed:

1. forensic photography
2. forensic evidential imaging
3. live forensic imaging
4. forensic radiology (medical forensigraphy)

The criminal justice system, although arguably also civil and insurance legal procedures (e.g. indemnity claims due to bodily harm), have the potential to benefit greatly from the results of forensigraphy. The contribution of forensigraphy in helping to ensure legal certainty is therefore immense (Krebs, Riener-Hofer, Scheurer, Schick, & Yen, 2011).

FORENSIC PHOTOGRAPHY

The term forensic photography applies to photographs taken to assist in the resolution of a criminal affair. This primarily involves visual documentation and preservation of the physical state of crime scenes, victims and suspects, for which photography is currently the method of choice (Martin, Delémont, Esseiva, & Jacquat, 2010). At the crime scene, overview photographs, or even a 3D registration, can assist in recording the positions of victims, objects and traces in a precise and faithful manner. Such photographs can be used to help respond to questions regarding the sequence of events or modus operandi (MO) of a particular event (Martin, et al., 2010). Detailed photographs of traces left at a crime scene (e.g. biological fluids, fingerprints, footwear marks or tool marks) preserve the state, dimensions and positions of such traces for later expert analysis (Martin, et al., 2010). Photographs of the victim's (or suspect's) physical state obtained close to the time of a crime are also a valuable form of evidence which can substantiate injuries or traces of violence in court. In addition to photographs taken using plain lighting, it is also possible to use various light sources which may enhance the visibility of findings that are otherwise hard to observe or document in plain light. For example, infrared (IR) photography uses an appropriate light source, sensors and filters to obtain images which have different optical properties, providing supplementary information (Farrar, Porter, & Renshaw, 2012).

In the context of clinical forensic medicine, photography of external injuries is of utmost importance. Although not considered imaging in the narrowest medical sense, as it does not involve the application of diagnostic imaging techniques to obtain internal human imaging data, clinical forensic photography is nevertheless an external registration of the human body which can assist in the resolution of questions related to criminal activities. A clinical forensic photograph can, although need not, be taken by a specialist in forensic medicine during the course of an examination (Österreichische Strafprozeßordnung (StPO), 1975) and should include a suitable scale beside the wound in order to accurately record distinctive characteristics

such as any patterning as well as the size and shape of wounds (McLay, 2009).

FORENSIC EVIDENTIAL IMAGING

Imaging techniques for forensic evidence differ from those used to assess living persons. Generally, evidential imaging techniques focus on the characterisation of various traces following an incident. For example, to respond to questions in hit-and-run cases, infrared (FTIR) imaging can be used to examine the chemical nature of automotive paint and provide images for the comparison of evidence found at a crime scene and samples from a suspect vehicle (Flynn, O'Leary, Lennard, Roux, & Reedy, 2005). Additionally, imaging techniques can also be employed to enhance the visibility of latent fingerprints in cases of sexual assault. For example, MALDI-MS imaging has the ability to detect the chemical components of condoms and lubricating agents, meaning it can target fingerprint traces from people having handled these materials (Francese et al., 2013). In the analysis of firearm evidence, imaging techniques focusing on surface topography can enable the 3D comparison of various traces present on evidential and suspect bullets (Riva, 2011).

LIVE FORENSIC IMAGING

Live forensic imaging refers to the real-time registration, and often analysis, of images, including video. Such techniques are useful not only in resolving illegal activities, but often also as a means of preventing such offences. Video surveillance serves both of these purposes. In addition to acting as a potential deterrent, surveillance devices can help identify suspects and victims through the registration of physical and non-conscious characteristics (race, build, facial features and gait) (Bouchrika, Goffredo, Carter, & Nixon, 2011; Nixon, Tan, & Chellappa, 2010). They are also useful in establishing the sequence of events at a crime scene. Other real-time forensic imaging techniques are present in various aspects of airport security. For example, X-ray scanners are often used to examine luggage for signs of criminal activity, including smuggled items, potential weapons and explosives (Wells & Bradley, 2012). In recent years, a number of airports have also implemented biometric measures, such as facial recognition and fingerprint scanning, to increase the efficiency and security of processing arrivals (Malčík & Drahanský, 2012).

FORENSIC RADIOLOGY (MEDICAL FORENSIGRAPHY)

The term medical forensigraphy consolidates the performance and interpretation of diagnostic medical imaging procedures with the resolution of judicial affairs (Brogdon, 1998). Medical imaging techniques provide internal data from human bodies, which, in the context of medical forensigraphy can be used to investigate a criminal offence. In medical forensigraphy, the 'objects' being imaged are therefore always people examined for forensic purposes. Medical forensigraphy represents an important scientific interface which broadly belongs to the field of criminalistics but at the same time is also affiliated with medicine, within which it is uniquely assigned to the branch of forensic medicine. Forensic medicine addresses requirements concerning both medico-legal questions, as well as criminal proceedings and is essentially 'the application of medical knowledge to the administration of law and to the furthering of justice' (Camps, 1976). It is concerned not only with the examination of the dead, as is primarily portrayed to the public, but additionally with the diagnosis and assessment of injuries of surviving victims, and at times, offenders.

Radiological procedures, such as computed tomography (CT) and magnetic resonance imaging (MRI), have already demonstrated their utility in clinical therapeutic patient care. Their application in forensic medicine presents the opportunity to ascertain additional, objective and verifiable information in relation to injury findings, thereby improving the quality of appraisals offered in legal proceedings, especially those concerning the type and extent of violence exerted against a person. Here, without fail, a close collaboration between experts in forensic medicine and radiology is essential. Each of these experts, in addition to the knowledge of their own speciality, requires the input of the other, with an optimal result arguably reached by a combined, supplementary approach.

To date, this approach has shown a general utility in the investigation of both the living and deceased (Thali, Dirnhofer, & Vock, 2009), and a specific utility in assessing the extent of tissue damage in subcutaneous fat (Yen, et al., 2004),

in detecting and characterising traumatic scalp injuries (Malli, Ehammer, Yen, & Scheurer, 2013), in assessing cases of strangulation (Yen, et al., 2007) and in estimating the age of individuals for forensic purposes (Scheurer, Quehenberger, Mund, Merkens, & Yen, 2011). Furthermore, existing image visualisation and forensic reconstruction possibilities are constantly advancing in line with technology. Such advances have led to the combination of computer graphics and computer vision techniques to facilitate forensic case analysis workflow, resulting in an interactive framework which can prepare raw medical imaging data for presentation in a court of law (Urschler, et al., 2012). This ability to depict complex internal medical findings in a way which is understandable for laymen is an important advantage when presenting legal evidence (Sherman, 2006).

Medical forensigraphy is further internally differentiated, depending on whether imaging data are obtained during a post-mortem or *in vivo* investigation. According to whether the application of forensic radiology concerns a deceased or surviving victim, the terms post-mortem forensigraphy or clinical forensigraphy are employed respectively.

POST-MORTEM FORENSIGRAPHY

Post-mortem forensigraphy deals with the application of diagnostic medical imaging in cases of suspicious death and requires a forensic pathologist (Österreichische Strafprozeßordnung (StPO), 1975). A specific methodology relevant here is one developed at the Institute of Forensic Medicine at the University of Bern. The 'virtopsy' approach, where the term is compiled from the words 'virtual' and 'autopsy', serves to reconstruct and document bodily injuries with the help of imaging procedures (Thali, 2002; Thali, et al., 2009). Using modern imaging techniques, a virtual 3D model of the deceased, on which internal and external injuries can be recorded, is created. This method essentially preserves the integrity of the deceased body (Dirnhofer, et al., 2010) while allowing the collection of tissue and fluid samples using minimally invasive techniques. Additionally, all medical imaging material obtained can be permanently archived as evidence, for later analysis and review as required. The benefits of such imaging techniques in post-mortem examinations lie particularly in their minimally invasive character and consequentially in the associated social and legal advantages. According to an international survey of users and providers of post-mortem forensigraphy, the use of cross-sectional imaging, compared to an invasive autopsy, would be preferred by the general public (National Health Service (NHS) Implementation Sub-Group of the Department of Health Post Mortem Forensic and Disaster Imaging Group (PMFDI), 2012). The tolerance threshold in relation to minimally invasive post-mortem examinations is quite low and as such, they enjoy a relatively high acceptance, especially in contrast to invasive techniques which can still today evoke religious and cultural conflicts (Segal, 2009).

CLINICAL FORENSIGRAPHY

The term clinical forensigraphy addresses the clinical application of medical imaging techniques, referring specifically to the use of such procedures on living persons for forensic purposes. Clinical forensigraphy falls within the domain of clinical forensic medicine, where medical knowledge and techniques are used to assess living persons in order to assist police and prosecution services in the investigation of offences (McLay, 1996). The examination of living persons requires the clinical forensic physician to apply their expert knowledge to preserve potential evidence and to accurately document (including photography) and interpret injuries (Santucci & Hsiao, 2003). In cases of suspected abuse, the recognition of factors which distinguish accidental and non-accidental injuries is especially important (McLay, 1996). Furthermore, a comprehensible objective presentation of medical findings and the eventual expression of an expert opinion as to how injuries may have been caused is often required to assist the judicial process (McLay, 2009).

Due to an increasing sensitivity and willingness of the public to expose cases of domestic and sexual assault (Minister of Justice of the Republic of Slovenia, 2009), as well as violence against children, the forensic appraisal of living persons is gaining more and more significance. The 'gold standard' for such forensic evaluations is currently still limited to an external physical examination of the body and minimally invasive procedures such as drawing blood samples. Although it is impossible to imagine modern diagnosis or therapeutic treatment without radiological imaging, such procedures are rarely undertaken in the absence of medical indication.

The integration of imaging techniques for forensic purposes, that is, to obtain information regarding internal injuries which could be useful in responding to judicial questions, including the type and degree of force exerted against a person, is relatively new. This integration, is the research focus of the LBI-CFI situated in Graz, Austria (Ludwig Boltzmann Institute for Clinical Forensic Imaging).

LEGAL CONSIDERATIONS

Clinical forensic physicians are confronted with many aspects of criminal and civil law as well as professional rights and obligations. When commissioned by the prosecution service, the expert is often additionally governed by national criminal procedural provisions for forensic examinations. Furthermore, since clinical forensigraphy involves the application of diagnostic medical imaging procedures to living persons, it also falls under legislation governing medical examinations of a person. The following specific considerations therefore arise when clinical forensigraphy is presented as an option in the investigation of judicial affairs:

(a) commission of clinical forensigraphy examinations;

(b) performance of clinical forensigraphy examinations;

(c) forensigraphy examinations; and

(d) admissibility of clinical forensigraphy material.

In addition to the specific regulations governing criminal proceedings and clinical forensigraphy material, (i.e. the use of imaging for forensic purposes), the more globally established protection against infringements on fundamental rights should not be disregarded. Forensigraphy can involve the visual preservation of a person's body or private possessions for evidential purposes in a judicial affair. This requires an intrusion into the private sphere, and in the case of clinical forensigraphy possibly an encroachment on physical integrity. The intensity of this intrusion can vary depending upon whether it involves naked full-body photographs, x-ray examinations, CT scans or radiation-free MRI. In addition to these fundamental infringements into the private sphere and on physical integrity, data protection obligations also need to be carefully considered.

CLINICAL FORENSIGRAPHY: AN AUSTRIAN LEGISLATIVE EXAMPLE

An analysis of Austrian law presents an opportunity to gain insight into the aforementioned legal considerations associated with clinical forensigraphy.

Commission of clinical forensigraphy material

Due to the emerging nature of clinical forensigraphy, legislation in Austria currently makes no direct reference to the inclusion of such material in legal proceedings. This means that obtaining clinical forensigraphy material is often achieved through direct communication between the prosecution service and the forensic medical expert to whom the mandate for an expert report is addressed. In such cases, expert competence and discretion play an extremely important role.

Performance of clinical forensigraphy examinations

According to legal provisions in Austria, an inspection of an undressed person may only be performed by a person of the same sex or a doctor ('Österreichische Strafprozeßordnung (StPO)', 1975). Forensic photography of a partially clothed person by law enforcement officers is additionally permitted (Österreichische Strafprozeßordnung (StPO), 1975). However, medical forensigraphy constitutes a medical examination of a person and therefore the presence of a physician is expressly required to undertake post-mortem ('Österreichische Strafprozeßordnung (StPO)', 1975) and clinical forensigraphy.

Consent requirements

According to national legal provisions governing medical practices ('Ärztegesetz', 1998), all medical examinations, including those stipulated by the penal code (Österreichisches Strafgesetzbuch (StGB), 1974), require the consent of the parties involved. Any person undergoing a clinical forensic examination must therefore partake of his/her own free will, and must also be informed and made aware of the risks associated with the radiological procedure.

Their 'informed consent' is therefore required. In cases involving clinical forensigraphy, i.e. when medical imaging techniques are employed in addition to a traditional physical examination, the task of obtaining the informed consent of the person submitting to the examination is not a trivial matter. Primarily, the acceptance and understanding of radiological examinations as well as concerns regarding radiation exposure and examination duration come into play (Scheurer & Schoelzke, 2013). A relevant exception to the requirement for consent is for the examination of a suspect, whereby according to Austrian procedural law, an examination can be conducted when the accused is suspected of having committed an offence punishable by more than 5 years' imprisonment (Österreichische Strafprozeßordnung (StPO), 1975).

Admissibility

If the conditions for a clinical forensic examination are fulfilled and the examination is lawfully prescribed, the results are admissible as evidence in criminal proceedings (Österreichische Strafprozeßordnung (StPO), 1975). Furthermore, results of a medical examination not undertaken for forensic purposes, including any relevant medical imaging materials may also be admitted as means of evidence if they are considered essential in proving a criminal offence (Österreichische Strafprozeßordnung (StPO), 1975).

DISCUSSION

PRACTICE AND POLICY IMPLICATIONS

The multi-disciplinary nature of forensigraphy establishes it as a broad discipline in which diverse services are offered by a number of providers. A clarification of the technical and legal frameworks in play is therefore essential in facilitating a structured and effective implementation of forensigraphy in practice. Key players such as police officers, prosecution services, courts and policymakers should be made aware of the potential contribution of imaging methods in the investigation of judicial affairs. Additionally, these 'end-users' need to know where and from whom certain information can be obtained, and the processes involved in obtaining such material. Of utmost importance in the domain of medical forensigraphy, are the considerations surrounding imaging of living persons, for which certain medico-legal requirements need to be adhered to. Conditions governing the use and execution of such imaging procedures in law enforcement are enshrined, or will be enshrined in the future, in the relevant legislation. Enacting and modifying such legislation requires a terminological summary of forensigraphy, for which a clear definition, as well as a systematic workup and structuring of its content is essential.

CONCLUSIONS

Together with a formal definition, this overview introduces the reader to the term forensigraphy by clarifying imaging terminology and presenting the reasoning behind the inclusion of forensigraphy in the field of criminal sciences, specifically within the domain of criminalistics. Furthermore, examples of forensigraphy in practice and an expansion of the term 'medical forensigraphy' are presented. Recent developments in post-mortem and clinical forensigraphy highlight the dynamic and quickly evolving nature of this interdisciplinary domain and also indicate its rising significance in forensic investigations. The considerable amount of research and development in the realm of forensigraphy, especially regarding new uses and possible applications, requires an open-ended list of applications and further makes the presentation of conclusive research results difficult. Developments in forensigraphy are strongly dependant on technical progress and in certain domains, medical advances. For this reason, a constant revision of the research-related status quo is important. Given the opportunities presented by medical forensigraphy, and when looking to move towards a more structured and formalised integration of these techniques in routine case work, an in-depth consideration of the legal framework and the need to balance legally protected interests were found to be essential. Based on the existing literature, the recommendation emerges that future research in the field of forensigraphy should focus on both technical developments and their specific applications in forensic medicine, as well as on the legal considerations relevant to effectively implement forensigraphy methods into the justice system.

REFERENCES

Ärztegesetz (1998) In: BGBl. (Bundesgesetzblatt) 1998/169 idF 2013/81. Austria: BGBl.

Bouchrika, I., Goffredo, M., Carter, J., & Nixon, M. (2011). On using gait in forensic biometrics. *Journal of forensic sciences*, 56, 882–889.

Brogdon, B. G. (1998). *Forensic radiology*. Boda Raton, FL: CRC Press.

Camps, F. E. (1976). *Gradwohl's legal medicine* (3rd ed.). Chicago, IL: Yearbook.

Dirnhofer, R., Schick, P. J., & Ranner, G. (2010). Virtopsy — Oduktion neu in Bildern. In (Vol. 33). Vienna: Manzsche Verlags- und Universitätsbuchhandlung.

Farrar, A., Porter, G., & Renshaw, A. (2012). Detection of latent bloodstains beneath painted surfaces using reflected infrared photography. *Journal of forensic sciences*, 57, 1190–1198.

Flynn, K., O'Leary, R., Lennard, C., Roux, C., & Reedy, B. J. (2005). Forensic applications of infrared chemical imaging: Multilayered paint chips. *Journal of forensic sciences*, 50, 832–841.

Francese, S., Bradshaw, R., Ferguson, L. S., Wolstenholme, R., Clench, M. R., & Bleay, S. (2013). Beyond the ridge pattern: multi-informative analysis of latent fingermarks by MALDI mass spectrometry. *Analyst*, 138, 4215–4228.

Krebs, N., Riener-Hofer, R., Scheurer, E., Schick, P. J., & Yen, K. (2011). Rechtsmedizin an Lebenden: Die erst österreichische 'klinisch-forensische Ambulanz'. *Österreichische Richterzeitung*, 89, 6–12.

Levin, K. (2012). Imaging and radiology. In A. D. A. M. H. Solutions (Ed.), *Medline Plus*: National Institutes of Health.

Lexikon-Redaktion. (1999). *Roche Lexikon Medizin* (Vol. 4). Munich: Urban & Fischer Verlag.

Malčík, D., & Drahanský, M. (2012). Anatomy of biometric passports. *Journal of Biomedicine and biotechnology*, 2012, 8.

Malli, N., Ehammer, T., Yen, K., & Scheurer, E. (2013). Detection and characterisation of traumatic scalp injuries for forensic evaluation using computed tomography. *International Journal of legal medicine*, 127, 195–200.

Martin, J. C., Delémont, O., Esseiva, P., & Jacquat, A. (2010). *Investigation de scène de crime: Fixation de l'état des lieux et traitement des traces d'objets* (3rd ed.). Lausanne: Presses polytechniques et universitaires romandes.

McLay, W. D. S. (1996). *Clinical forensic medicine* (2nd ed.). London: Greenwich Medical Media.

McLay, W. D. S. (2009). *Clinical forensic medicine* (3rd ed.). Cambridge: Cambridge University Press.

Minister of Justice of the Republic of Slovenia. (2009). Breaking the silence — united against domestic violence. In *29th Conference of Council of Europe Ministers of Justice*. Tromso, Norway.

NHS Implementation Sub-Group of the Department of Health Post Mortem Forensic and Disaster Imaging Group (PMFDI). (2012). *Can cross-sectional imaging as an adjunct and/or alternative to the invasive autopsy be implemented within the NHS?* United Kingdom.

Nixon, M. S., Tan, T., & Chellappa, R. (2010). *Human identification based on gait*. New York: Springer.

Österreichische Strafprozeßordnung (StPO) (1975). Austria: BGBl.

Österreichisches Strafgesetzbuch (StGB). (1974). Austria: BGBl.

Püschel, K. (2007). Schöne neue Welt von Virtopsy, Autopsy Imaging, Radiosektion und Nekroradiologie. *Rechtsmedizin*, 17, 5–6.

Riener-Hofer, R. (2013). Bildgebung und Forensik: Forensigraphie. *Kriminalistik — Unabhängige Zeitschrift für die kriminalistische Wissenschaft und Praxis*.

Riva, F. (2011). *Etude sur la valeur indicielle des traces présentes sur les douilles*. Unpublished Doctoral dissertation, Université de Lausanne.

Santucci, K. A., & Hsiao, A. L. (2003). Advances in clinical forensic medicine. *Curr Opin Pediat*, 15, 304–308.

Scheurer, E., Quehenberger, F., Mund, M., Merkens, H., & Yen, K. (2011). Validation of reference data on wisdom tooth mineralisation and eruption for forensic age estimation in living persons. *International Journal of legal medicine*, 125, 707–715.

Scheurer, E., & Schoelzke, S. (2013). Consent to forensic radiologic examinations by living crime victims. *International Journal of legal medicine*, 1–6.

Schwegler, I. (2004). Digitale Fotografie bei Polizei und Justiz — Chancen und Risken aus rechtlicher Sicht. *Aktuelle juristische Praxis (AJP)/Pratique Juridique Actuelle (PJA)*, 6, 657–667.

Schwind, H. D. (2011). *Kriminologie*. Heidelberg: Kriminalistik Verlag.

Segal, G. P. (2009). Legal Side. In: Thali, M. J., Dirnhofer, R. & Vock, P. (Eds.), *The virtopsy approach* (pp. 27-40). Boca Raton, FL: CRC Press.

Sherman, S. (2006). A digital forensic practitioner's guide to giving evidence in a court of law. In: Valli, C. & Woodward, A. (Eds.), *4th Australian Digital Forensics Conference*. Edith Cowan University, Perth, Australia.

Siller, H. Gabler Wirtschaftslexikon, Stichwort: Forensik. In: Springer Fachmedien Wiesbaden GmbH — http://wirtschaftslexikon.gabler.de/Archiv/1408495/forensik-v2.html (Access date: 11.04.2013).

Thali, M. J. (2002). Virtopsy. In (Vol. 2013).

Thali, M. J., Dirnhofer, R., & Vock, P. (2009). *The Virtopsy Approach*. Boca Raton, FL: CRC Press.

Urschler, M., Bornik, A., Scheurer, E., Yen, K., Bischof, H., & Schmalstieg, D. (2012). Forensic-Case Analysis: From 3D Imaging to Interactive Visualisation. *Computer Graphics and Applications, IEEE, 32*, 79–87.

Wells, K., & Bradley, D. A. (2012). A review of X-ray explosives detection techniques for checked baggage. *Applied Radiation and Isotopes*, 70, 1729–1746.

Willersinn, D. (2011). Biometriebasierte Forensische Personsuche. http://www.iosb.fraunhofer.de/servlet/is/23023/ (Access date: 11.04.2013).

Yen, K., Vock, P., Christe, A., Scheurer, E., Plattner, T., Schön, C., Aghayev, E., Jackowski, C., Beutler, V., Thali, M. J., & Dirnhofer, R. (2007). Clinical forensic radiology in strangulation victims: forensic expertise based on magnetic resonance imaging (MRI) findings. *International Journal of legal medicine, 121*, 115–123.

Yen, K., Vock, P., Tiefenthaler, B., Ranner, G., Scheurer, E., Thali, M. J., Zwygart, K., Sonnenschein, M., Wiltgen, M., & Dirnhofer, R. (2004). Virtopsy: forensic traumatology of the subcutaneous fatty tissue; multislice computed tomography (MSCT) and magnetic resonance imaging (MRI) as diagnostic tools. *Journal of forensic sciences, 49*, 799–806.