FINGERMARKS, BITEMARKS AND OTHER IMPRESSIONS (BAREFOOT, EARS, LIPS) –

A REVIEW (SEPTEMBER 2004 – JULY 2007)

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ABSTRACT

The purpose of this paper is to review the scientific literature from about September 2004 to July 2007. The review is focused on more than 280 published papers in scientific journals or proceedings. The review will not cover information coming from international meetings available only in abstract form.

Fingermarks constitute an important chapter with further discussion on the identification process as well as detection techniques on various surfaces. We note that the research has been very dense both at exploring and understanding current detection methods as well as bringing groundbreaking techniques to increase the number of marks detected from various objects. No doubt that the recent challenges the discipline has faced (mainly in the US through *Daubert*-type challenges) has promoted a fresh look at various techniques that were taken as fully understood. We note the same trend when it comes to the identification process. From the alarming state of affair we exposed in our last report, various research groups have attempted to address the issues from a variety of perspectives: psychological, perceptive and cognitive research, analysis of error rates and statistical modelling of partial fingermarks.

Other biometric means of forensic identification such as footprint, earmarks, lipmarks and bitemarks, are showing an very active research activity. A substantial set of reports explored the evidential contribution of earmarks. The work carried out under the EU funded project FEARID has been now largely published. Special attention has also been given in the literature on bitemark evidence with a view to improve the reliability of the discipline.

We invite the reader to use two levels of reading for this report: a summary level and a more detailed level. In each subsequent section, if the number of papers published in a given area is large, the subsection will start with a quick summary (in a paragraph defined with a right and a left border lines) followed by a more detailed analysis of the research at hand

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1. Introduction

In 2005 and 2007, Brettell *et al.* published two concise reviews of the forensic literature from January 2003 to December 2006 (1, 2). These reviews covered three main areas of interest: forensic DNA analysis, trace evidence, and drugs/poisons. David Rendle proposed a so-called *tutorial* about the analytical problems facing the forensic chemist and the current methods and techniques employed to tackle them (3). The covered subjects were various, *i.e.*, firearms, toxicology, drug, explosives, fibres, paint, glass, soil, arson scenes, and inks, and could thus be of a good interest for a global approach to forensic chemistry research issue.

This paper constitutes a complement to these reports and will be focused on marks and impression evidence. It will cover the scientific literature from September 2004 to June 2007. Because of the amount of material covered, this report does not intend to be a critical review but merely a point of focus and organisation of the available material. The material reviewed primarily originates from peer-reviewed journals and published books although non-reviewed electronic sources may at some points be used. Proceedings of colloquies will be used only when available in the form of full paper conference proceedings. We will try to cover here more than 280 references and, of course, we run the risk of having missed important material. In advance, we apologise to any author(s) or organisation(s) whose contribution(s) should have been mentioned. We also would like to thank individuals, peer groups and organisations that kept us informed of current developments and initiatives in the areas covered in this report.

Broeders set nicely the present state of play in identification sciences (outside the DNA arena) (4). Traditional identification disciplines are increasingly requested to meet the same standards (in terms of transparency and underpinning statistical studies) as DNA evidence. Judiciary and legal scholars are becoming more and more critical of these well-established disciplines (see for example (5)). As Broeders wrote (p. 157): “the criticism is beginning to produce fresh research efforts aimed at improving forensic identification methods, which are frequently undertaken in an international context. Harmonization of methods and techniques, as well as quality control is high on the forensic agenda.” We attempted through this report to bring in a single and coherent place all published work aiming at advancing these disciplines.

During the reviewing period, reference books have been published, covering the recovery, comparison and evaluation processes. We propose to introduce them upfront. We may in the next sections come back to specific chapters of contributed books.

A large contributed volume has been published in German covering criminal investigation issues for judges and lawyers including chapters devoted to marks and impressions (6). In the same vein, we recall the regularly updated version of *Modern Scientific Evidence* (7).

In the area of fingerprint evidence, we note the following important contributions:

The Home Office Scientific Development Branch published a major revision of their Manual of fingerprint development techniques (8).

Stoilovic and Lennard published the third edition of the fingerprint detection and enhancement manual used at the Australian Federal Police. It brings an update on the latest detection techniques deployed operationally with emphasis on optical enhancement techniques (9).

Michelle Triplett issued her fingerprint dictionary: a reference guide for fingerprint examiners to the who, what and where of fingerprint identification (10). The dictionary is also available on-line at: http://www.fprints.nwlean.net/.

The McKie case has been covered by a book published by the father of Shirley McKie and Michael Russell (11). All documents associated with the inquiry into the Scottish Criminal

Record Office and Scottish Fingerprint Service by the Justice 1 committee are available online at: http://www.scottish.parliament.uk/business/committees/justice1/reports.htm. Refer also a short paper published in CAC News (12).

Two books provide a welcomed coverage of fingerprint identification in general, one by Bill Leo (13), the second acting as a reference guide for investigators by Craig Coppock (14).

Bitemark evidence received a full treatment that constitutes a welcomed addition to any forensic library (15).

Biometrics (including AFIS technology) is becoming a field in its own and we decided to limit drastically its coverage in this review. We do however want to point towards the recent publication of a few books that are important:

Komarinski published a book on AFIS systems with special chapters on the procurement process (16).

Issues in relation to multibiometric systems are very close to the issues facing forensic scientists when combining evidence from multiple source and nature. The state of the art in the biometric field is presented by Ross *et al.* (17).

The guide to IAFIS recently published is a good addition (18). Edgubov gave an interesting overview of the research towards the development of the Russian AFIS (19). Also the recent work on level 3 features is very promising (20). The reasons to move from a two-finger system towards a 10-finger system for the US VISIT programme have been presented in the light of the associated error rates (21). The quality of images is at the core of current issue in the management of large forensic image databases. The research in the fingerprint area is very active as well and as been recently reported (22).

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2. Fingermarks

The importance of the Internet for sharing of information is ever increasing. One source of weekly updates, especially on fingerprint identification issues is the "*weekly detail*", an e-mail newsletter maintained by Kasey Wertheim, which can either be consulted online (www.clpex.com), or received through email under subscription. Jon Stimac is proposing a newsletter now entitled "*DactyloGram*" which can be downloaded from the *Pacific Northwest Division of the International Association for Identification* website (http://www.pnwdiai.org/publications.php). Likewise, the *Southern California Association of Fingerprint Officers* (SCAFO) is putting their publication "*The Print*" online (http://www.scafo.org/Online_Information/ThePrint_online.htm). The HOSDB (*Home Office Scientific Development Branch*, previously known as PSDB) does publish regularly the results from their research work on latent marks, operational methods, or new techniques of interest. These newsletters can be obtained directly from the HOSDB website (http://scienceandresearch.homeoffice.gov.uk/hosdb/fingerprints-footmarks/fingerprint-publications). Part of the publication will be used here when relevant. We do encourage the community to take advantage of these reports often available previous to publication in forensic journals. The same applies to the research work done at the *Royal Canadian Mounted Police* (RCMP). Research reports can be downloaded from http://www.cprc.org/.

Various groups of fingerprint practitioners are also active in making information available to the community. The FBI sponsored *Scientific Working Group on Friction Ridge Analysis, Study and Technology* (SWGFAST) published on the Internet all their proposed standards (www.swgfast.org). The reports from the work carried out under the umbrella of Interpol from the fingerprint working parties are also available online (http://www.interpol.com/Public/Forensic/Default.asp), including the presentations given at the International Symposium on Fingerprints (May 17-19, 2006). The publication by the *Interpol European Expert Group on Fingerprint Identification* of their second report is of primary importance in times where international collaboration and standards should prevail. This report is very well written and highlights the major practice within Europe without falling into the sterile debate between practitioners referring to a numerical standard and practitioners applying a holistic approach (23).

The ENFSI fingerprint working group also publish information online (http://www.enfsi.org/ewg/efpwg/). Charles Parker (Charles.Parker@ci.austin.tx.us) is coordinating an exchange list FIG (Fingerprint Interest Group), dedicated to the sharing of friction ridge images to other persons interested in the "Science of Fingerprints" for the purpose of education and training.

Information available over the Internet is abundant. Peer reviewed journals stay, however, the qualitatively most important source of information, and cannot be replaced completely by online forums.

We take notice of a small paper of historical importance showing the crucial work carried out by Indian Pioneers in collaboration with E. Henry to develop the now famous Galton-Henry system (24). Giving credit to these workers has been often forgotten. Polish colleagues reported on the introduction of dactyloscopy for the State Police in 1919 (25).

2.1. Friction ridge skin individualization process

Various reports of critical importance have followed the discovery of the wrong individualisation of Brandon Mayfield. A report details the findings and recommendations made by the internal review teams (26, 27). The main recommendations were: revisions in the latent print training program, revisions to evidence-acceptance policies, detailed revisions to SOPs (Standard Operating Procedures) and casework documentation policies and procedures, revisions to SOPs regarding the decision-making process when determining the comparative value of a latent mark, and more stringent verification policies and procedures. An internal scientific review team explored and prioritised on the main research issues facing the fingerprint profession in order to provide the transparent underpinning to the friction ridge skin identification process (28). A paper by Kent from the UK argues in the same direction (29). The report of the office of the Inspector General regarding this case has also been released (30). Four critical areas have been identified:

- the fact that the known impression from Brandon Mayfield was showing a degree of similarity (10 minutiae could be described in correspondence) with the true source;
- the fact that circular reasoning could have convinced examiners of the presence of distinctive features on the mark whereas their visibility was established on the known impression first;
- the misleading conclusions from the analysis stage with regards to the number of marks available (double tap) and a questionable reliance on level three features;

– the potential bias of the verification stage caused by the knowledge of the conclusions of the first examiner when the mark was checked by the next has been highlighted.

All these reports should be considered by any laboratory doing friction ridge skin individualisation. The Mayfield received a wide coverage both in the press (ex. (31)) and also among forensic scientists (32).

Two courts decisions need to be brought to the attention of the fingerprint community:

(1) The issue of the individualisation of simultaneous impressions was brought up in the case *Commonwealth v Terry L. Patterson* (33). The court expressed strong reservations in accepting evidence where individual comparisons do not standalone and when the decision is made by aggregating information from more than one mark (in a case of marks left by adjacent fingers in an anatomical sequence). Two Amicus briefs rightly highlighted the issues at hand when dealing with aggregates of marks (34, 35). It received press coverage as well (36). The case initiated some research efforts that have been published. Black shows that examiners have the ability (with a relatively small error rate) to make informed decisions as to whether or not fingermarks had been left by a single hand simultaneously (37). The study also showed the critical factors to consider.

(2) A recent court decision in a case in New Hampshire forces to think about the level of documentation required in case notes and the status (blind or not of the verification stage) (38). In *State of New Hampshire v. Richard Langill*, Judge Coffey excluded the fingerprint identification as presented, arguing that the laboratory case notes in relation to the fingerprint examination were not contemporaneous and the verification process was not conducted blindly.

The scientific status of identification evidence and in particular fingerprint evidence still receives critical attention from scholars and commentators (5, 39, 40). Simon Cole in particular published a series of paper pointing out some critical aspects of latent fingerprint identification (41-45). Although the pressure from Courts in relation to admissibility issues under *Daubert*-type challenged has reduced, the scientific community remains very active at highlighting issues that fingerprint examiners should be prepared to address (46). Every case of wrong individualisation is brought to light (47) and may be a topic of examination in court. The protocols and methods used to conduct fingerprint examination received coverage (48, 49) and have been debated (50). Knowledge of the morphogenesis and the biological process involved remains an essential part of the expert's knowledge to articulate his evidence in court. Maceo published a detailed account of the mechanism of skin healing following injuries to the friction ridge skin pattern (51) and Siegel published a general overview on friction ridge skin formation (52). Following his PhD thesis (53), Kücken published three essential papers detailing the mathematical model that can be postulated for the formation of general pattern of fingerprints (54-56). Based on an exhaustive literature review of friction ridge skin morphogenesis, the authors argue that the general pattern results from a buckling (folding) process in a cell layer of the epidermis. A predictive mathematical model to support this hypothesis has been designed and tested.

Research aiming at identifying the potential bias examiners may be victim of made significant progress (57-60). This empirical research highlights the existence and the need of a full awareness of the impact of contextual information on the decision making of fingerprint examiners. The studies by Dror *et al.* are mainly focused on the final decision arising from the comparison.

Preliminary work by Schiffer & Champod tends to suggest that a proper ACE-V protocol, with a clear and distinct analysis and comparison phase may diminish the risk of bias (61). Similar results have been obtained for footwear mark examiners in the Netherlands (62). Expectation showed no impact on the examiner's decision making. Examiners seem to compensate for the low quality of marks by increasing cautiousness thanks probably to the strict examination guidelines with an explicit assessment of the contribution of the acquired features as a function of their complexity. Practitioners are nowadays fully aware of the potential for bias and rightly recognize the need for proper training and operational procedures to mitigate the risk (63).

A pilot study by Langenburg shows how fingerprint experts are more proficient in the analysis phase compared to novices (64). The research by Busey and Vanderkolk identified for fingerprint experts perceptual abilities not available in novices thanks to EGG component analysis. The results showed that experts have qualitative differences as well as overall better performance on behavioural tasks (65).

Recent studies in relation to the statistical evaluation of partial fingermarks can also be viewed as part of the answer to recent challenges (66-68). Using different models, these recent researches have shown that the selectivity of partial fingermarks is very high – even down to three minutiae configuration– and that partial fingermarks could be easily assessed through the use of likelihood ratios. These models are mainly based on minutiae, but despite the fact that they embrace limited information from friction ridge skin, the random match probabilities involved compete with DNA profiling. Minutiae frequencies received some coverage in the literature for the Polish (69) and Spanish population (70). These data are intended to help examiners calibrate their judgment as to the rarity of given level 2 features. The use of a likelihood ratio framework to approach forensic individualisation from biometric data is now widely advocated as shown by Meuwly in his comprehensive review (71).

At the heart of the issues lies the question of the error rate associated with fingerprint practitioners. Using data gathered from training classes, Wertheim *et al.* suggested that this error rate is low (72). The validity of data gathered in such a training environment and their relevancy to actual casework has also been discussed (73). At the moment, apart from results obtained from declared proficiency testing, the analysis of the errors committed in training environment remains the only indicator for the profession.

Czarnecki reported cases of laterally inverted fingermark impressions obtained after chemical treatments, and discussed about the importance of having in mind such possibilities during the "Analysis" step of the ACE-V process (74). The use of ridge density to predict sex has been explored by Kaur & Garg (75). The use of whorls features to predict the hand has been brought back to examiners' attention (76). Similarly general pattern allows predicting to some degree the finger number and ethnicity (77). Even level 2 features can help in predicting the most likely region of interest thanks to the fact that the deltas are attracting the creation of ridges towards them (78).

2.2. Fingermark composition, detection and visualisation

This chapter is structured as followed: after a paragraph dedicated to the composition and behaviour under various conditions of the fingermark residue, the work in relation to different detection techniques will be presented. We also separated from the mainstream techniques applicable on various substrates, the techniques devoted to blood impressions, thermal papers, adhesive tapes and when items are collected from arson scenes. A good introduction to fingerprint detection techniques has been published by Voos-de-Haan and can serve as a good starting point for readers not accustomed to the range of methods available in the field (79).

2.2.1. *Composition and aging of fingermarks*

> The knowledge of the chemical changes that take place on fingermarks once they are left on a surface should enable new and improved visualization methods to be developed, for example, by targeting the products that are formed as the marks age. Different studies aimed at understanding what are the effects of time (80, 81) and extreme temperature (82) on the fingermark components, how the ingestion of alcohol could modify the secretion mixture (83), and aimed at determining how gas chromatography – mass spectroscopy (GC/MS) could help in identifying the composition of the fingerprint residue (84, 85). Finally, the penetration ability of amino acids in paper matrix was also studied (86).

Archer *et al.* tried to increase our current knowledge of the fingermark chemistry by studying the composition of a latent fingermark over time, and more particularly, the evolution of the lipid fraction (80). The protocol consisted in collecting sebaceous fingermarks on small pieces of glass fibre filter paper, aging them under controlled conditions, extracting the secretion with dichloromethane, co-derivatizing it with MSTFA and finally analyzing it by GC/MS. In direct relation with this work, further investigation was carried out to identify the oxidation products of squalene (SQ) in latent fingermarks (81). The analyses confirmed that SQ was rapidly depleted from marks. By day 7, SQ is no longer detected. The oxidation products of SQ should make suitable targets for development of new reagents able to visualize latent fingermarks.

When the fingerprint residue is submitted to extreme temperatures, the conventional development techniques for latent fingermarks sometimes fail to detect marks. This could happen when a weapon cartridge is fired, an improvised explosive device is detonated, and/or in arson cases. A study aimed to understand how these extreme temperatures alter the chemical and physical properties of latent fingermark residue (82). The authors identified 3,6-dimethylpiperazine-2,5-dione (from alanine), maleimide, and 2,5-furandione (from aspartic acid) as pyrolytic decomposition products from fingermarks and as potential targets for new reagents.

Another study aimed at analyzing the effect of drinking on the composition of sweat secretions. Indeed, fatty acid ethyl esters (FAEE) are known to be formed in blood and almost all human tissues after alcohol consumption and to be incorporated from sebum into hair. In order to examine whether the skin surface lipids are an equally useful matrix for measurement of FAEE as alcohol abuse markers, samples were collected by a wipe-test from several volunteers or cadavers involved or not in drinking activities (83). It was concluded from the results that FAEE in skin surface lipids can be used for medium-term retrospective detection of heavy drinking. It should be noted that a transition time of about 8 days between sebum production and its appearance on the skin surface was observed.

Zhang *et al.* proposed a non-invasive method based on solid phase microextraction and GC/MS to analyze the volatile organic emanations from the skin of human arms (85). Thirty-five compounds were identified (alkenes, alcohols, alkanes, aldehydes, …). Croxton *et al.* compared three solvents systems for the simultaneous extraction and derivatization with ethyl chloroformate of selected amino and fatty acids for subsequent analysis by GC/MS (84). This method was applied to the analysis of latent fingermark residue deposited on Mylar. Twelve amino acids and ten fatty acids (*e.g.*, tetradecanoic, hexadecanoic, and octadecanoic acids) were identified. Further studies are however required to validate this method and to apply it to the chemistry of latent fingermarks.

Finally, Almog *et al.* observed the penetration ability of sweat (more particularly, the amino acids) in the cross section of paper by fluorescence microscopy (after having treated the samples with DFO and 1,2-indanedione) (86). An inverse relationship between the smoothness of the paper and the penetration depth was observed: higher smoothness values resulted in lower depths of penetration. Moreover, high quality prints appear to be correlated with an optimal penetration depth between 40 and 60 microns.

2.2.2. Physical and chemical detection techniques

After having reviewed the literature about the different techniques allowing to detect latent fingermarks, it appeared that there is currently a strong determination to optimize and homogenize the different formulations that could exist for a given method, that is, 1,2-indanedione (87) and genipin (88). Comparative analyses between detection techniques have also been conducted, being made as surveys (89, 90) or as laboratory experiments (91).

Except for the new pre-mixed "metal / ninhydrin" formulation proposed by Almog *et al.* (92), the literature dedicated to ninhydrin consisted in structural reviews or mechanism explanations (93, 94), as well as various potential applications (95, 96). Moreover, the look for efficient "dual fingermark reagents" (defined as compounds that produce impressions that are both coloured and fluorescent in one stage) was still leading the scientific research, with genipin or 1,2-indanedione as powerful successors for DFO and ninhydrin (97, 98), especially since a pre-mixed metallic version has been proposed (99). It should be noted that no paper was directly related to DFO, since 1,2-indanedione seems to monopolize the scientific attention.

The understanding of the cyanoacrylate polymerization mechanism has been thoroughly studied (100-105), the other articles being focused on the fuming method (101, 106, 107) or on the potential detections of drugs in fingermarks (108).

The use of powders to detect fingermarks led to two distinct research orientations: (1) the "classical" powders, with three extensive surveys from the HOSDB about their adequate use (109-112), the proposition of new fluorescent powders (113-117), application and detection studies (118, 119), and SPR (120-122); and (2) "intelligent" nanopowders, which consist of functionalized nanoparticles able to target more efficiently the secretion components (123-128) or incorporating fluorescent markers in their inner structure (129).

Other techniques were also improved or studied to understand their underlying mechanisms. It was the case for multimetal deposition (130-132), physical developer (133-135), Oil red O (136-138), Europium complexes (139, 140), vacuum metal deposition (141-143), camphor (144) and Sudan black (135).

All these studies are described in more details below according to each technique.

2.2.3. Comparative surveys and experiments

The results of a survey, sent to state police laboratories in Australia and New Zealand and to members of major fingerprint research groups and laboratories around the world, indicated a high degree of variability in the reagent formulations employed for developing fingermarks on porous surfaces (*e.g.*, 16 different ninhydrin formulations and 18 different DFO formulations), mainly for cost issues (89). A lack of awareness for 1,2-indanedione has also been highlighted, even if its efficiency has been proved to be superior to DFO and ninhydrin. In 2005, a questionnaire sent in fingerprint bureaux across Scotland showed that the most popular treatments are ninhydrin for porous surfaces and superglue for shiny non-porous ones, physical developer and DFO being fairly less used (90).

The performance of two spray reagents, iodine-benzoflavone (I_2-BNZ) and ruthenium tetroxide (RTX), was evaluated and compared with powdering, the conventional technique used at the crime scene. Neither the spray techniques nor powdering were shown to be suitable for all surfaces and ages of marks (91). On some surfaces, such as glass and treated wood, and for all ages of marks, powdering was still the superior technique, whereas I_2-BNZ produced better development on wallpaper, vinyl, brick, and raw wood. Sequencing work showed that I_2-BNZ can be used successfully either before or after powdering in a sequence, but was incompatible with cyanoacrylate fuming. RTX was the best technique for fresh marks and marks aged up to one day on wallpaper and paint, but is incompatible with powdering and cyanoacrylate in sequence. Good results with RTX have been reported in Poland, acknowledging the fact that old marks are difficult to detect with this reagent (145).

2.2.4. Ninhydrin / genipin

Some research is still performed on ninhydrin, as recently shown by Almog *et al.* who proposed a pre-mixed solution containing ninhydrin and group IIb metal salts (*i.e.*, $ZnCl_2$ and $CdCl_2$) (92). This "Ninh-MIIb" formulation seems to be as efficient as the two-step process beginning with ninhydrin and followed by a metal salt treatment, with a higher sensitivity in the fluorescence mode. When compared with genipin, Ninh-MIIb exhibits a higher sensitivity in the shorter wavelength domain. The genipin is however advantageous in the longer wavelength domain on paper items with strong self-fluorescence (brown wrapping paper or paper printed with fluorescent ink). In 2005, a review of the different synthetic approaches used in the development of ninhydrin analogues has been published, with some of the newest analogues and methods developed to date (93). From a purely theoretical point of view, Petraco *et al.* presented a computational study of the formation of Ruhemann's Purple from the combination of ninhydrin and alanine (94). These two articles could be useful when developing alternatives to the current generation of ninhydrin-like chemicals. Two applications of ninhydrin were also proposed: Sun *et al.* presented a way to efficiently quantify amino acids in solution by using the ninhydrin absorbance (96); Voller *et al.* presented a medical application of ninhydrin by modifying the "ninhydrin sweat test" (NST) which consists in analyzing the development of a patient's palm trace on paper (95).

An optimized formulation of genipin has been proposed by Levinton-Shamuilov (88), that is, 0.17g genipin in 57ml ethyl alcohol and 86ml ethyl acetate, filled up to 1L with HFE7100 (or petroleum ether). Optimal development conditions were determined to be 15min at 75-85°C and 80% relative humidity. On brown wrapping paper and on papers with highly luminescent backgrounds, genipin developed more visible and clearer marks than did classical reagents such as ninhydrin or DFO.

2.2.5. The use of 1,2-indanedione

1,2-indanedione (IND) was first proposed as an amino acid reagent for latent fingermark detection in 1997. It is considered as a true dual fingermark reagent since it is both coloured and luminescent. These last years, research groups around the world aimed at optimizing the technique and comparing the efficiency of IND with both ninhydrin and DFO. However, there has been no general consensus in terms of preferred formulation, development conditions, metal salt treatment, observation conditions, and relative performance compared to conventional techniques. Wallace-Kunkel *et al.* investigated the best formulation and development procedure under Australian conditions, encompassing all published recommendations as well as some novel approaches (87). Five IND formulations were compared with respect to the initial colour, the fluorescence, the concentration of reagent, the acetic acid concentration, and the effect of different carrier solvents. The recommended IND formulation was finally: 1g 1,2-indanedione in 10ml acetic acid and 90ml ethyl acetate, completed to 1L by HFE-7100 (stable indefinitely). The heat press set at 165°C for 10 seconds proved to give the best initial colour and most intense luminescence when the sample is placed between two sheets of paper towel. Finally, the Polilight® forensic light source was the most suitable instrument for the detection of fingermarks treated with IND.

A new indanedione-zinc (IND-Zn) formulation has also been proposed by Stoilovic *et al.* (99). According to the authors, the detection capabilities are improved compared to DFO, with results that are less dependent on the relative moisture content of treated fingermarks. The new combined IND-Zn reagent was prepared by the addition of a small amount of zinc chloride solution to an optimized IND formulation. The fingermarks were finally developed in a dry heat press at 160°C for 10 seconds. The application of a one-step IND-Zn process developed latent fingermarks that were generally more intense in color and in luminescence compared to the conventional IND reagent, with an increased sensitivity.

To better understand the underlying chemical mechanisms, Alaoui *et al.* proposed a mass-spectra and time-resolved fluorescence spectroscopy study of the reaction between IND and glycine, and identified two fluorescent reaction products (97). And, finally, in an attempt to determine if IND may interfere with DNA analysis, Yu & Wallace treated fingermarks deposited on two substrates (thermal and carbonless paper), before swabbing them completely and performing a PCR-STR DNA typing (98). The results showed that IND did not adversely affect the DNA profiles obtained from the treated fingerprints. Partial DNA profiles were obtained at all post-development time frames.

2.2.6. Cyanoacrylate

The use of superglue vapours to detect latent fingermarks on non-porous (or semi-porous) surfaces is a chemical process that has not been fully understood yet. Some theories suggest that superglue reacts with organic fingermark deposits, amino acids, or proteins, as well as chloride ions which would catch water molecules, but no consensus seems to emerge from all these hypotheses. The role of the fingermark material in the formation of methyl (or other alkyl) cyanoacrylate (CA) polymer remains thus to be established. Many scientific efforts and analyses were thus dedicated to this goal. Czekanski *et al.* proposed a model in which the monomers can accumulate in the oily film of the finger secretion (104). For this, they used films of liquid alkanes (n-dodecane, undecane, hexadecane) to simulate actual fingermarks. The accumulation of superglue monomers into a thin film (or wax) seemed to be consistent with the preferential response of fingermarks on surfaces relative to the background. From another point of view, Kent explained, in a letter to the editor, that the optimum value of 80% relative humidity (RH) allows solid crystals in the latent fingermarks to absorb water. By doing this, they become liquid droplets that provide a source of water initiating the CA polymerisation (101). Mankidy *et al.* used a scanning electron microscope to observe the catalytic growth of cyanoacrylate nanofibres on fingermarks, while controlling the RH (102). They confirmed what was observed in forensic laboratories, that is, that, at a very high RH, the polymerisation is rapid and located on the ridges of fingermarks. At a low RH (<30%), only film-like polymers were generated or no polymer at all. They also tried to identify the polymerisation initiators by putting each component to fuming conditions. Sodium chloride, stearic acid, palmitic acid and amino acid resulted in nanofibre growth, but of different morphology than the one observed in actual fingermarks. This study highlighted thus the role played by the complex composition of the sweat on the CA polymerisation. Another group also performed several studies on CA-fumed fingermarks using Raman spectroscopy to study the polymerisation of the CA monomers (100, 103) or to locate drugs in fingermarks (108, 146). About this last study, the authors succeeded in detecting dopant particles in fingermarks with spectra of a similar quality to the reference ones. It should however be noted that particularly doped fingermarks were used for this experiment and it is not known if actual cases would consist in the same quantity of drugs on the fingertips. The observation of CA-treated fingermarks showed that unreacted polymers still remain in the mark after fuming and could thus react with exogenous compounds to modify their key spectral signature (103). For information, near-infrared spectroscopy has also been used to study the effect of water and film thickness on the CA polymerisation process on glass (105).

HOSDB indicates that the current water-based formulation of Basic Yellow 40 (BY40) as a superglue dye has inferior performance to the ethanol-based formulation, with a lower luminescence. An alternative is thus proposed with a water-based formulation of Basic Red 14, which is brighter than the water-based BY40 formulation. This new formulation is thus recommended to use on crime scenes (106).

From an operational point of view, Bessman *et al.* tested two CA fuming cabinets: a humidity cabinet (a modified glove box providing precise control of both the CA vaporization temperature and the humidity level) and a vacuum chamber (in which the pressure could be controlled over a wide pressure range) (107). They determined that both the humidity (with 60% RH) and the vacuum cabinets produced better results (*e.g.*, less background colouring and sharper, clearer ridge details) on most substrates than marks developed in a heating-only cabinet. They also observed that a dye stain made with methanol as a carrier instead of petroleum ether gave better, clearer results, especially with Rhodamine 6G (R6G). Terry Kent answered to this article saying that it has already been clearly shown that the humidified superglue process is extremely effective and under normal circumstances will substantially outperform non-humidified or vacuum systems (101). Moreover, it has been previously determined that a 80% RH is the optimum value. He also argued that most police forces in Europe installed humidified systems in the early 1990s based on the PSDB design and that R6G in methanol is toxic and should be replaced by BY40 in ethanol.

Rosati confirmed that superglue fuming of guns and rifles had very limited impact on subsequent firearms identification work (147).

2.2.7. "Classical" powders and Small Particle Reagent (SPR)

Fingerprint powders have been successfully used for over 100 years for the detection of latent marks at scenes of crime. This success is closely linked to the fact that powders are low-cost, efficient, and present no excessive health and safety issues. However, a survey conducted in England by the HOSDB indicated huge differences in the habits of scene examiners. Since the choice of the powder, brush, lifting media, etc. can influence the quantity and quality of developed marks, the HOSDB researchers decided to perform extensive laboratory trials to give some guideline for the use of powder on crime scenes. First, they studied the best brush to use with aluminium powder on surfaces commonly encountered at crime scenes (109). Second, they evaluated the performance of the most commonly used powders on the most commonly occurring smooth surfaces (110). Third, they gave some advices for the powdering of surfaces which generally yield fewer marks, such as textured surfaces and u-PVC (111). Finally, Bandey proposed a Fingerprint Powders Guideline, based on the three previous studies (112). The results of these three major studies are:

– The glass fibre brush is the most appropriate for the aluminium powder, for most surfaces. As an alternative, the squirrel zephyr style or the tapered polyester brushes can be used. The artist squirrel brush is one of the least effective on all surfaces. The overall conclusions are similar between fresh and old marks. Additionally, spinning the brush during application of the aluminium powder offers no advantage in terms of development;

- Flake powders generally outperformed granular ones on smooth surfaces. Glass should thus be powdered with aluminium powder unless contamination prohibits its use, and magnetic powders should be used on surfaces that are not perfectly smooth. On painted metal, the effectiveness of all the powders on the non-metallic painted metal was greater than on the metallic painted surface; however the relative performances of the powders were similar, except for the white powder that was considerably less effective. For the ceramic tile, none of the flake powders appeared to be any more sensitive than the granular powder (as it is usually the case on other tested surfaces). For gloss painted wood, magneta flake and black magnetic considerably outperformed aluminium powder and black granular respectively;
- Aluminium powder and black granular powder should not be used on textured surfaces;
- Where appropriate, a black or jet black magnetic powder should be used on textured surfaces, u-PVC window and door frame. The authors also indicated that some of the textured surfaces studied in this trial would give better results, in terms of marks developed, if chemically treated in a fingerprint development laboratory.

Several cases of relatively old marks developed with powders have been reported in the literature over the years. In the study presented by Azoury *et al.*, latent marks were deposited on two types of smooth substrates (Formica board and white PVC shutter elements), exposed to different storage conditions in two geographic sites, and developed with powder at various intervals for a total period of nine months (118). It was found that identifiable fingermarks could be easily developed with magnetic powder, even months after being deposited. In this experiment, no correlation could be found between the age of the marks and their physical appearance. The authors recommend thus to refrain from commenting on fingermark age unless having specific information pertaining to the particular case.

Sodhi & Kaur proposed several new components to be included in fluorescent powder formulations, that is, cyano blue dye (113), proflavin (114), nile red with bean seed powder (115). According to their observations, these new powders gave sharp and clear marks on a wide range of absorbent and non-absorbent surfaces (paper, polyethylene bags, laminated documents,…), including multi-colored ones. A comparative assessment of the different powdering methods previously proposed by Sodhi *et al.* has been performed on different substrates (*i.e.*, bond paper, plastic sheet, glass, and multicoloured paper) by Saroa *et al*. (116, 117). As a conclusion, it appeared that charcoal powder was more suitable on bond paper, while the other powders (*i.e.*, phloxine B, fluorescein, and rhodamine B) gave better results on the three other surfaces. A consistent trend showed that positive results decrease as the marks are aging. Seah *et al.* proposed to use the time-resolved imaging of fingermarks developed with fluorescent powders to improve their contrast (119). This technique can be useful when the mark is deposited on fluorescing background with an emission wavelength close to that of the treated fingermark.

The detection of fingermarks on wet surfaces still constitutes a major problem. Small Particle Reagents (SPR) is a commonly used solution which allows to detect latent fingermarks left on wet or moist surfaces based upon the reaction between the fatty-acid residuals present in the traces and hydrophobic tails of the specific reagents. An experiment performed on immersed plastic (vinyl acetate), glass and painted metal wet surfaces (up to one month), showed no influence of the time of immersion and the type of surface in the quality of the results (121). According to the authors, only the way the surface has been touched and the time the contact lasted play a role. Another study showed that Tergitol-7 can be replaced with saponin, a naturally found surface-active compound (122). Being based on charcoal powder or basic zinc carbonate, the SPR solution was found to work satisfactorily even after 15 days of storage in ambient conditions. Finally, Cucè *et al.* (120)

presented a casework in which SPR has been successfully applied on a completely dust covered bottle.

2.2.8. Functionalized nanoparticles

A new trend has appeared in the forensic literature these last years: the functionalization of nanoparticles (*e.g.* gold, silver, silica) to obtain "intelligent" nanopowders presenting an enhanced affinity for lipid materials and fluorescence abilities. This new generation of powders (or suspensions) have been placed in a specific section of this report, to differentiate them from the "classical" powders. Nanopowders which would be preferentially attracted to the lipid-containing components of the fingermarks were obtained by coating metal nanoparticles (gold and silver) with oleylamine (long-chain lipophilic molecule) (123). These nanopowders were compared with conventional powders and it was shown that gold produced sharp and clear development of latent fingermarks without background staining, even if less contrast is generally observed compared to black powders. All the powders produced at least satisfactory performance on glass and painted wood, but the fingermarks on the plastic and aluminium surfaces were more difficult to develop, especially when fingermarks were not fresh. Additionally, the authors successfully tried to enhance ridge detail by following the procedure with a physical developer. This study has been followed by the combination of oleylamine with a fluorescent dye (perylene dianhydride) (125). This entity was absorbed onto titanium dioxide nanoparticles to form a new powder exhibiting strong fluorescence at 650-700 nm under excitation at 505 nm. Compared with current magnetic fluorescent powders, the new powder was slightly weaker in fluorescence intensity but produced significantly less background development, resulting in good contrast between the fingermark and the substrate. Similarly, Sametband *et al.* synthesized gold nanoparticles and quantum dots functionalized by n-alkanethiols and n-alkaneamine, respectively, and solubilized them in petroleum ether (128). After an immersion time of about 3 minutes in such a solution, a silver physical developer (Ag-PD) was applied to form dark impressions on the ridge details. According to the authors, the hydrophobic capped gold nanoparticles improve the intensity and clarity of the developed prints compared with Ag-PD alone. Quantum dots can be visualized immediately due to their fluorescence under UV illumination.

Leggett *et al.* presented a way to detect specific drug metabolites in a fingermark, to provide evidence of the use of a drug (and not only touching contaminated objects) (126, 127). Without entering into the details, cotinine (a metabolite of nicotine present in the sweat of tobacco smoker) is targeted with anti-cotinine antibodies bound to gold nanoparticles and combined with a fluorescent marker. Highly detailed fingermarks, with 3rd level minutiae were obtained. The functionalization of gold nanoparticles to enhance the detection of fingermarks has also been tested by Becue *et al.* (131); this paper is described in the "Multimetal deposition" section.

A novel fluorescent dusting composition based on nanoparticles of aluminium oxide has also been formulated (124). These particles have been coated with two types of molecules: Eosin Y (a fluorescent dye) and a natural hydrophobic substances so that fingermarks may be detected on most surfaces. According to the authors, the novel composition detects fingermarks on a wide range of surfaces, absorbent and non-absorbent; white and multicoloured. It is particularly suitable for developing fingermarks on glossy items, as well as on moist and sticky surfaces. The developed marks showed yellow-green fluorescence when illuminated at 550nm.

Theaker *et al.* chose to enclose a variety of coloured and fluorescent molecules (fluorescein, thiazole orange, oxazine perchlorate, methylene blue, BY 40, BR 28, rhodamine B and rhodamine 6G) into silicate particles (129). The resulting doped particles can be produced as nanoparticles (used as aqueous suspensions) or microparticles (used as dusting agents). Both fresh (20min) and aged fingermarks (40 days-old) presented a good definition after development.

2.2.9. Multimetal deposition (MMD)

The Multimetal deposition (MMD) still constitutes a powerful method to detect fingermarks on various surfaces, even if it is less used due to its heavy experimental procedure. Two modifications of the standard MMD process are reported in the literature. First, in an attempt to reduce the number of immersion baths to a minimum, the gold nanoparticles were functionalized with molecular hosts (*i.e.*, thiolated cyclodextrins) able to bind to gold while keeping their ability to bear dye guests in their inner cavity (131). This new formulation has been tested on three different surfaces to attest the feasibility of this strategy. Successful results were obtained, with detailed fingermarks offering a good contrast to allow their identification without the need to enhance the results (such as with a physical developer). Another modification of the MMD consisted in replacing the silver enhancement of the gold colloids by a gold enhancement procedure (132). Named Single-metal deposition (SMD), this new formulation allowed to reduce the number of baths by one as well as the number of reagents and their cost, utilized reagents with a longer shelf life, and most importantly reduced labour-intensity procedures. It offers quasi-identical results to MMD and thus makes a very attractive alternative.

To investigate the binding of gold nanoparticles to fingermarks on nonporous surfaces, Choi *et al.* chose to observe them using a scanning electron microscope (130). As previously observed by Schnetz & Margot (148), the results showed that gold nanoparticles bind preferentially to the latent fingermark ridges. Variation in the surfactant concentration influences the background development but does not affect the binding of gold nanoparticles to the ridges, while pH variation influences the binding to ridges but leaves valley regions unaffected.

2.2.10. Physical developer (PD)

Yapping & Yue presented a new physical developer (PD) formulation that requires only two solutions (133). According to the authors, the new PD can develop latent fingermarks on porous and nonporous surfaces and latent fingerprints on adhesive tape. It is stable, simple, inexpensive, does not need maleic acid pre-treatment, as well as no surfactant. It should however be noticed that this formulation has been tried by Cantu who reported that the PD was so unstable that it was not possible to apply it (134). The working solution immediately turned dark-green and a precipitate appeared, whereas authors claimed their solution to be stable for two days. When trying to apply this solution, Cantu observed some very weak results with one-day-old prints and concluded that the solution acts as some sort of "small particle reagent".

The HOSDB proposed a technique to reduce the final steps of the PD procedure, that is, the sample can be fixed with a photographic fixer and washed in tap water instead of using an extended washing regime in distilled water (135). However, if photographic fixer is used, re-treatment to improve contrast or detail is not possible.

Wilson *et al.* performed a systematic study to examine the effect of the acid pre-washes and water rinses on paper bearing latent marks before their treatment with a silver PD (149). Malic acid at a concentration of 2.5% proved to be an ideal acid for most papers, providing good fingermark development with minimal background darkening. Water rinses were deemed unnecessary before physical development.

2.2.11. Oil red O (ORO)

Oil Red O (ORO) is a lysochrome that can be used to detect latent fingermarks on porous surfaces that have been wet, by selectively coloring lipid marks, leading to red ridges on a pink background.

Beaudoin carried out tests on various types of paper and cardboard, with few-days aged fingermarks (136). Compared with a physical developer (PD), the ORO technique appeared to be much less complex and gave results with good clarity and intensity. Following these observations, Rawji & Baudoin compared ORO and PD on three types of surfaces: thermal, standard white and brown kraft papers (137). ORO was consistently superior to PD in terms of the mean fingermark quality produced on thermal paper. It should be noted that thermal papers would lose the writing or information that was on them when in ORO (it is not the case with PD). The authors also concluded that no effect of the aging of the fingermarks has been observed (in the 1- to 30-day time frame of the experiment) for the white paper, but observed a detrimental effect on the kraft brown paper. Beaudoin's group further explored how ORO can be incorporated in fingerprint detection sequences (138). ORO can be efficiently added in a detection techniques between the amino acids reagents (DFO, ninhydrin, indanedione) and the physical developer (PD).

Miscellaneous detection techniques (Europium, VMD, camphor, etc.)

EUROPIUM - Two new fluorescent developers based on the Europium were proposed in the literature. First, a multiple component chelate was tested on fresh marks (3-5 days) deposited on porous and nonporous surfaces (139). No background staining was observed and, according to the authors, this product can be used repeatedly during months without loss of quality. A second compound consists in amino-functionalized europium oxide nanoparticles that target carboxylic acid functionalities of the fingermark constituents (140). Experimentally, the procedure requires to immerse the sample in an aqueous solution containing the reactive compounds and to heat it to 70-80°C for 30min for optimal results. Without heating, no development was observed. It has to be noted that very fresh fingermarks (5 hours) gave good results, whereas one-week-old marks gave poor ridge details.

VMD - Vacuum metal deposition (VMD) is a well-established technique that can be used for the development of latent fingermarks on difficult semi-porous surfaces (polymer banknotes) as well as on a range of polymer surfaces. Normal VMD development is characterised by zinc depositing all over the surface except on the fingermark ridges (leading to an inverse fingermark). Dai *et al.* aimed at visualising the formation of gold agglomerates on a Formvar (polyvinyl formal) polymer surface by transmission electron microscopy (TEM), to gain an appreciation of how the density and size of these agglomerates changes with an increasing amount of evaporated gold (142). TEM images have confirmed the formation of gold clusters under vacuum, instead of a uniform gold layer. This study has also put in evidence a relationship between the agglomerate size and density with increasing quantities of evaporated gold. Further studies are however required to establish the statistical reproducibility of these results on other polymer substrates, as well as the relationship between gold agglomerate size and density and resulting zing deposition. Another paper reported an alternative VMD process capable of developing fingermarks on articles for which the existing gold and zinc process gives poor results (*e.g.*, clingfilm, plasticized polymers) (141, 143). It was demonstrated both in a laboratory and in operational trials that additional fingermarks could be developed by depositing silver after the conventional gold and zinc process, and the technique is now recommended for operational use. The optimum quantity of silver was defined as the amount giving a mid-purple colour to the background. Pursuing the exploration of alternative metal for VMD, a Canadian group recently showed how aluminium can easily replace in a one-step process the cumbersome gold followed by zinc depositions (150). The effect of age has been clearly highlighted for the VMD process. Marks older than 90 days showed more difficulties to be detected compared to more recent residues. Sebaceous secretions are more favourably detected than eccrine secretions.

CAMPHOR - The camphor fuming technique was applied on different unfired cartridge casings and compared with three conventional methods (cyanoacrylate, pyrrole electropolymerization, and silver nitrate) (144). The camphor fuming technique consists in burning camphor crystals to allow a black carbon to deposit on the ridges of a latent mark. Excess carbon is wiped off with a feather brush or under running water. This method is inexpensive, non-toxic, nonabrasive, present no risk of overdevelopment and the resulting marks can be transferred on plates. One week-old latent prints on the aluminium, brass, lacquered brass, nickel-plated brass, and copper, revealed better quality ridges as compared to the traditional techniques, even if the cartridges have been wet. For most of the varnished steel, a strong background noise was observed. Marks older than three weeks could not be developed.

SUDAN BLACK - The HOSDB introduced of a new formulation of Sudan black (Solvent black 3) to be applied on contaminated surfaces at scenes of crime (135). It is particularly effective on non-porous surfaces that are too sticky for the use of powders and where superglue is ineffective.

2.3. Forensic light sources, photography and digital/chemical imaging

The initial use of alternative light source constitutes an ideal non-destructive method to detect marks or stains (from finger or other sources) before any physico-chemical or chemical treatment. In this domain, a forensic light source (FLS such as Polilight® or Crimescope®) constitutes an efficient non-invasive method that has been applied on computers (151), fabrics (152), or human skin (153, 154). Some authors reported the well-known use of a laser as an alternative powerful light source also able to detect fingermarks (135, 155-158). Recently, micro-X-ray fluorescence was reported as a potentially good technique to selectively detect the chemical elements in fingermark residue (141, 159-161). But from all these techniques, the chemical imaging (CI) has certainly constituted the main subject of interest for many researchers. By combining spectroscopy (FTIR, Raman, …) with digital reconstruction/visualization, CI has proved to be efficient in detecting fingermarks on difficult surfaces or for various applications (162-168). Other techniques such as Kelvin probe (169), time-resolved imaging (170-172) or scanning electrochemical microscopy (173) may also be useful for forensic use.

The photography of fingermarks has also been the subject of different papers: use of infrared filters (174), ultra-violet scale (154), 3D reconstruction (175), and development of the digital photography allowing to numerically enhance some marks (176-179).

2.3.1. Alternative light sources such as Polilight® or Crimescope®

The use of a versatile light source (such as a Rofin Polilight PL 500) may assist in the detection of potential semen, saliva, and bloodstains on a large range of textile substrates (colored cotton, nylon, satin, synthetic carpet, etc). Vandenberg & van Oorschot studied the effect of dilution, as well as the potential background of laundry detergents, on the visualization of such traces using a Polilight (152). The Polilight® was compared with conventional-based screening tests such as acid phosphatase (for semen), Phadebas (for saliva), and luminol (for blood). The Polilight® was able to locate stains that were not apparent to the naked eye on a variety of materials (wool, cotton, nylon, polyester and blends), with only one false-negative result on 40 casework exhibits. Its sensitivity was lower than that of luminol to detect bloodstains, but it has particular application in instances where a bloodstain may have been concealed with paint (wavelength: 415nm). Other fluids were tested (urine, tea, vaginal and nasal secretions) and were detected under Polilight® at 450nm, 415nm (blood and urine), and 505nm (semen and urine).

The detection of potential fingermarks and toolmarks in a computer system (especially the user-replaceable components such as hard drives) has been studied using a Mason-Vactron's CrimeLite® 5W LED light source (151). The authors evaluated this non-invasive method of mark location, by minimizing the contact with the components, and recommend a new procedure for the handling of digital evidence sources which may contain "conventional" evidence. The best results were obtained using the blue light source, to visualize fingermarks on finished metal.

Photographing evidence with ultraviolet radiation ultimately involves presenting the information to subjects who may have no prior experience at viewing these wavelengths. Dyer *et al.* proposed a calibrated ultraviolet reflecting grayscale allowing meaningful interpretation of results on human skin for example (154). Another project aimed to determine if an alternative light source could be utilised to assist investigators estimating the age of a bruise (153). The statistical results indicated that there was no correlation between time and the mean densitometry values.

2.3.2. Laser

Menzel *et al.* described the field methodology for photoluminescence detection of traces of explosives as well as latent fingermarks (155). Their instrumentation was simple, battery-powered, highly portable, and usable in a daylight environment. The technique allowed the visualization of Lanthanide-based tagging by suppressing the strong background luminescence that can occur on some surfaces.

Inherent fluorescence spectra and imaging of fingerprints were studied in the deep ultraviolet (UV) region with a nanosecond-pulsed Nd-YAG laser system that consisted of a tunable laser, a cooled CCD camera, and a grating spectrometer (157). The UV fluorescence spectra of fingermarks, which were illuminated under a wavelength of 266 nm, showed two main peaks: one around 330 nm (peak A) and another around 440 nm (peak B). At first, when a finger has just been pressed, the peak A is dominant. However, its intensity reduces as the total illumination time increases. On the other hand, peak B is weak at first and its intensity increases as time elapses. The same authors also studied the fluorescence imaging of fingermarks on a high-grade white paper (158). Clear fluorescence images were obtained by time-resolved imaging with a 255 to 425 nm band-pass filter, which cuts off strong fluorescence of papers. Absorption images of latent fingermarks on a high-grade white paper were also obtained with this imaging system using 215 to 280 nm laser light. Shorter wavelengths produce better images and the best image was obtained with 215 nm. Absorption images were slightly degraded by laser illumination, but their damage is smaller than that of fluorescence images. The HOSDB also mentioned the Nd:YAG laser with comparison with Quaser® 100 or Quaserchrome®, and its application on operational use (135, 156).

2.3.3. Micro-X-ray fluorescence (MXRF)

Scientists from the University of California working at Los Alamos National Laboratory have developed, through the use of micro-X-ray fluorescence (MXRF), a non-destructive technique that detects fingermarks by targeting the chemical elements mainly present in residue (*e.g.*, sodium, potassium, and chlorine), or due to lotion or sunscreen cream (159-161). MXRF is described as a nondestructive technique based on the observation of the emitted X-rays (characteristic of the elements present in the sample) after irradiation. It is however unable to detect carbon, hydrogen, nitrogen, and oxygen present in the organic compounds. It should be noted that the typical time for analyzing one fingermark is 10 to 20 hours – depending on the sample, and that *a priori* knowledge about the location of a mark is required. Further developments are thus necessary before considering this technique for operational use. In 2005, the HOSDB also mentioned the XRF microscopy of fingermarks as having a potential for fingermark analysis and capable of resolving fingermark ridges on patterned and textured surfaces (141). Toning techniques using heavy elements can also be used to enhance the contrast (*e.g.*, physical developer with iodine toning).

2.3.4. Photography

Bleay & Kent described a short study about the use of infrared filters in conjunction with a digital camera with sensitivity in the near infra-red region, to remove coloured background patterns from fingermark images (174). Indeed, many of the pigments used in printing inks are transparent when viewed in the infrared region of the spectrum This technique has been shown to be effective in removing multicoloured backgrounds from marks developed using physical developer, vacuum metal deposition, black powder suspension, aluminium powder and small particle reagent.

The success of digital photography of evidence or traces is tightly linked to the ability of using computer tools such as Photoshop. It is thus not a surprise that some articles are dedicated to the use or optimization of digital techniques. Chaikovsky *et al.* proposed the multiple exposure method to take pictures of substrate that are not uniform in terms of shape, color, and so forth - using digital photography and computerized image processing based on the layers methodology (177). The technique simply consists of aligning several pictures of the trace by digital superimposition through the use of layers. Another article gave some tips to capture 1:1 photographs with a copy camera and also described a simple way to resize images that were not taken at a 1:1 ratio, to use in AFIS systems (179). The use of High Dynamic Range (HDR) images could also be useful in forensic science, as proposed by Day & Wertheim (178). The HDR technique simply consists in taking different pictures of the same scene, in this case a fingermark on a surface, with different amounts of exposure and then to fusion them. For this pilot study, HDR images of fingermarks on different surfaces were found to consistently produce detail of higher quality than a normally exposed photograph. Although taking several photographs at different exposure and merging them together is more time consuming than simply taking a normal digital photo, it could provide the examiner with the ability to see the extra detail needed to identify a tough latent.

The 3D geometric documentation of injuries on the body surface and internal injuries in the living and deceased cases has also been presented (175). The authors used a TRITOP/ATOS II system to take multiple images of an object or a subject from different angles. Using modern imaging methods such as photogrammetry, optical surface and radiological CT/MRI scanning, they demonstrated that it was possible to answer reconstructive questions of the dynamic development of patterned injuries, and to evaluate the possibility that they are matchable or linkable to suspected injury-causing instruments. This technique also allowed to access 3D data of small, located injury or defects (*e.g.*, shoemark on the skin compared to a shoesole)

Finally, PrintIQ (a software developed by LumenIQ, Inc.) allows to translate the image intensity value at each pixel point in any digital image into a relative elevation point in a dynamic, interactive 3D surface map. It is designed to enable the human eye to visualize a broader spectrum of image intensity signals that can be seen with unaided vision (this is only re-representation) and should thus help examiners analyzing and comparing fingermarks, especially, on low-contrast marks (176).

Standard image processing techniques have not received a lot of effort during this reviewing period. It translates the fact that the technology is mature and innovation is slowing down. We note the use of differential hysteresis processing to enhance the visibility of low quality marks (180).

2.3.5. Chemical imaging

The possibility of using chemical spectral information to enhance forensic images has been discussed in several recent publications. The chemical imaging (CI) relies on the spectral specificity of reagents having distinctive spectral signatures, which are different from the background. CI is thus defined as the collection of spectral and spatial data in a short amount of time, for a sample, and their visualization as a full image at each individual wavelength or as a full spectrum for each pixel. It is for example possible to select reagents with narrow spectral features that lead to increased visibility using digital cameras and computer image enhancement programs even if their coloration is much less intense to the unaided eye than traditional reagents. This new method allows the collection of images from backgrounds that traditionally pose problems for current fingermark detection methods (for example, highly colored ones or with a complex pattern). A lot of work has thus been performed in the domain of CI to allow visualization of fingermarks on problematic surfaces.

To demonstrate the power and applicability of infrared CI, fingermarks fumed with ethyl cyanoacrylate were successfully imaged from Australian polymer banknotes, which have particularly difficult backgrounds for latent fingermark revelation (165). Some problems associated with interfering peaks in the infrared spectrum of the background material required a fingermark reagent with a sufficiently intense and isolated infrared absorption band to be selected without interfering with the background. Cyanoacrylate was chosen for this reason. It has however to be noted that the image collection time using this technique was typically of the order of four hours. Using the Condor® macroscopic chemical imaging system (ChemImage Corp., Pittsburgh, USA), Payne *et al.* also demonstrated that CI offers advantages over conventional visualization techniques when examining latent fingermarks (163). The Condor® significantly improved the detection of many marks, especially those that might be considered of a poor quality. Miskelly & Wagner illustrated the CI concept by visualising latent fingermarks on paper with the zinc complex of Ruhemann's Purple (from ninhydrin), cyanoacrylate-fumed fingermarks with Eu(tta)3(phen), and soil prints with 2,6-bis(benzimidazol-2-yl)-4-[4'-(dimethylamino)phenyl]pyridine (164). In each case, the background correction was performed at one or two wavelengths bracketing the narrow absorption or emission band of these compounds. The application of the multispectral methods (mathematical equations or combination of digital pictures) to the pictures taken for each trace at different wavelengths allowed to reduce the contribution of the background and to improve the signal of the traces. It has to be noted that infrared chemical (hyperspectral) imaging can also be used to analyze automotive paint chips in particular, and multicomponent samples in general (162). Recently, Ricci *et al.* proposed the attenuated total reflection Fourier transform infrared (ATR-FT-IR) spectroscopic imaging to monitor the effect of time and temperature on the fingermark components (168). This technique is said to be faster than the classical FTIR chemical imaging as used by Tahtouh *et al.* (165). The distribution of lipid and amino acid components in the fingermarks from different donors were studied with the focus put on the sebaceous material. When increasing the temperature, a general decrease in the absorbance of the main bands of lipid components has been observed which is postulated to be the result of the degradation to lower molecular weight components with subsequent volatilization. Concurrent with the increase of temperature, some IR bands broadened to completely disappear after 14 hours. This information could help in understanding the aging of the fingermarks and in increasing the likelihood of successful visualization by choosing the most-suited techniques.

The capability of Fourier transform infrared (FTIR) spectroscopic imaging to provide detailed images of unprocessed latent fingermarks was also demonstrated by Crane *et al.* (167). Unprocessed fingermarks were developed on various porous (copier paper, cigarette butt paper, US dollar bill, postcard) and nonporous (trash bags, soda can, tape) substrates. Chan & Kazarian, in an attempt to use FTIR for the detection of trace materials, also proposed this technique for forensic application, in the case of drug handling for example (166). To this purpose, a finger has been put in contact with caffeine (chosen as a model drug) then wiped before FTIR was applied directly on the fingertip.

2.3.6. Other non-destructive techniques

The current state of the art in fingermark visualisation on metallic surfaces by a scanning Kelvin probe (SKP) technique was described by Williams & McMurray (169). Some results were presented which showed that the SKP technique allowed to visualize fingermarks beneath optically opaque soot films and retrieve ridge detail in instances where marks have been physically removed (*e.g.*, by rubbing with a tissue) from a metal surface. SKP Volta potential mapping of small, severely non-planar metal objects such as fired brass cartridge cases was also demonstrated. It should be noted that almost 20 hours are required to get a high-definition partial scan and 6 to 8 hours to get a full fingermark with a lower definition image (20 dots/mm).

Time-resolved imaging is a technique based on the difference in fluorescence lifetimes (FL) between chemicals. It can be very useful in the forensic domain by allowing to eliminate unwanted background emission when visualizing a luminescent mark. Seah *et al.* successfully applied this technique to fingermarks treated with two magnetic fluorescent powders, by allowing to selectively visualize one powder and not the other (170). A theoretical analysis for the FL determination of latent fingermark samples has been described, and followed by the feasibility study of using FL imaging in frequency domain for latent fingermark detection (172). The resulting FL image of powdered fingermarks revealed a good contrast since the fluorescence of the powder has longer lifetime than the background, allowing to clearly visualize the latent fingermarks. Dinish *et al.* proposed to use a phase-resolved fluorescence technique for latent fingermark imaging (171).

Zhang and Girault published on the use of scanning electrochemical microscopy to visualise fingerprint detected with metals with a very high resolution (173).

2.3.7. Fingermarks in blood and detection of bloodstains

Different reagents are available to detect bloodmarks and a lot of comparative studies were performed to test their efficiency (181-184). The results of these studies showed that Bluestar Forensic® seems to be a powerful alternative to the conventional luminol (182, 183, 185).

Other blood-reacting reagents were also cited in the literature: luminol (186-189), Sudan black (135), Leuco rhodamine 6G (190) and Eosin Y (191). Some studies were dealing with the detection of bloodmarks on crime scenes (192) or the effect of time on them (193-195). The possibility to retrieve DNA from blood marks after treatment has also been studied (185, 196). Finally, mass spectrometry has been proved to be useful in forensic cases (197).

COMPARATIVE STUDIES - The HOSDB performed a systematic evaluation of the compounds reacting with the components of blood on various surfaces (porous, semiporous and nonporous) (181). The results showed that the techniques inducing a reaction or an interaction with the heme group, although being more specific for blood, are not as sensitive or as effective in developing fingermarks in blood as the techniques targeting the amines or proteins. Most effective on porous surfaces were DFO and ninhydrin (both HFE formulations), which react with amines. On nonporous surfaces, acid yellow 7 was determined to be a suitable replacement for the protein dye benzoxanthene yellow (not available anymore). The performance of Acid Yellow 7 is most marked on lighter deposits of blood, giving enhancement even where there is little or no evidence of its existence. A new formulation of amido black, based on a water/ethanol/acetic acid formula (WEAA) was proposed as a replacement for the water-based formulation. A sequence chart, based on the HOSDB recommendations, is also proposed. Marchant & Tague (184) compared four techniques used to chemically develop marks in blood (*i.e.*, amido black, coomassie blue, ABTS, and fluorescein). Neither the water-based formulation of amido black nor the fluorescein were very successful in developing latent fingermarks in blood, resulting in very poor useable marks. The other three methods performed similarly. ABTS and the methanol-based were the two methods that gave the better results on the porous and nonporous surfaces. Coomassie blue performed very well on porous items but lacked in giving good results on nonporous items. About the costs, fluorescein is the cheapest, followed by amido black, coomassie blue and ABTS (however, it should be noted that the cost calculation was based on the cost of the primary dye only, and did not take into account the solvents and additional chemicals). Finally, when considering the ease of use, coomassie blue and amido black ranked first. ABTS came after as it requires additional activation and fixation steps. To conclude, the methanol formulation of amido black seemed to be the best overall techniques for developing fingermarks in blood. However, the use of coomassie blue and ABTS should also be strongly considered according to circumstances.

BLUESTAR® - Several authors have shown their interests to the use of Bluestar® (Forensic) as a new efficient blood reagent, and compared it with luminol and fluorescein. A study performed on several surfaces (*i.e.*, maple wood, Olefin carpet, vinyl tile, ceramic tile, 100% cotton t-shirt, and dark blue CoolMax shirt) showed that Bluestar Forensic® has distinct advantages when compared to luminol, with outperformed results and much brighter traces (182). The authors also indicated that bleach removed any trace of blood from the majority of the surfaces. Young compared luminol, fluorescein, and Bluestar® using carpet pieces on which blood was transferred (183). The results showed that Bluestar® performs as well or better than luminol and fluorescein. Indeed, it does not require complete darkness (compared to luminol), does not require a forensic light source (compared to fluorescein), and present a long-lasting reaction time. According to the manufacturer, Bluestar® Forensic does not interfere with DNA analysis. To confirm this affirmation, Jakovich (185) collected marks developed using Bluestar® Forensic and performed STR analyses. Full profiles at the 13 core CODIS STR loci were obtained from swabs from each carpet, demonstrating the Bluestar® Forensic, like luminol and fluorescein, does not inhibit STR analysis. Martin & Cahill also demonstrated the successful recovery of DNA from a blood sample on denim substrates treated with fluorescein (196).

LUMINOL - Bily & Maldonado used luminol to determine whether blood could be detected through paint layers, in case of cover-up attempts (188). The results of this experiment showed that luminol was effective in detecting bloodstains through eight layers of paint. Webb *et al.* compared luminol with four non-chemiluminescent techniques able to detect blood (*i.e.*, phenolphthalein, leucomalachite green, Hemastix, and the forensic light source) (187). Bovine haemoglobin has been used for the tests and the results showed that luminol was the most sensitive technique, with Hemastix as an efficient alternative. The forensic application of luminol has also been reviewed by Barni *et al.*, who proposed an historical overview of the use of luminol and of the reaction mechanisms with blood (189). From an historical point of view, Tug *et al.* tried to solve the origin of the stain present on the wall of Kasimiye Medresse (Turkey) and considered to be the blood of an ancient Sultan (186). After having used luminol and analyzed the stain with X-ray diffraction, the mark turned out to a dye made of herbal roots.

NEW BLOOD REAGENTS - Leuco rhodamine 6G has been proposed as a new reagent since it reacts with the heme moiety of the haemoglobin (190)]. Developed fingermarks appear as red marks that can be visualized with a strong contrast. This technique can be used as a one-step spray method, since neither pre-treatment nor post-treatment are required. The best results were obtained on smooth surfaces, rather than on rough surfaces. The age of the blood marks (tested to four weeks) does not seem to play a role in their visualization. Eosin Y is usually used as a chemical dye but it also binds to the heme moiety of the haemoglobin molecules in blood, yielding to a red-colored complex (191). Six surfaces were tested (paper, unfinished wood, finished wood, painted woods, plastic notebook cover, glass sheet, metal sheet) and the marks were from 1 day to 4-weeks-old. The results were good for all the surfaces, with no difference between old and fresh prints.

VARIOUS - The applications of a matrix-assisted laser desorption/ionization mass spectrometry (MALDI/MS) were reported for two different forensic issues: human blood drop in a car carpet and identification of the dyes present in ink found on a rubber sole of a shoe (197).

Some studies were conducted to evaluate the age of bloodmarks. In a first study, electron paramagnetic resonance (EPR) was used to estimate the age of human bloodstains (194). This technique is based on measuring the denaturation of hemoproteins in dried bloodstains. The authors found a linear correlation up to 432 days with an error range within 25% of the actual number of days under controlled conditions. However, environmental factors such as differences of absorbent, light exposure and fluctuations of storage temperature affected the changes of these EPR-active compounds, which result in misestimating the time since bleeding occurred. Therefore, one should take such factors into account in estimating the period since bleeding by this method. Another study focused on the stability of the RNA over time to estimate the age of a bloodmark (193). The authors used real-time reverse transcriptase PCR to show that the ratio between different types of RNA (mRNA versus rRNA) changes over time in a linear fashion when dried human blood from eight individuals was examined over the course of 150 days. According to the authors, this approach offers the following advantages: enhanced detectability of small samples, simultaneous isolation of DNA and RNA from the same sample, species-specific probes, and an increased window of usefulness. Finally, atomic force microscopy has been used for high-resolution imaging of erythrocytes in a blood sample and the detection of elasticity changes on a nanometer scale (195). The elasticity pattern showed a decrease over time, which are most probably influenced by the alteration of the blood spot during the drying and coagulation process. The preliminary data demonstrates the capacity of this method for development of calibration curves, which can be used for estimation of bloodstain ages during forensic investigations.

The possibility of detecting the presence of human haemoglobin through a monoclonal-polyclonal antibodies system has been reported (192). This would allow to avoid useless laboratory analysis, that are expensive and time consuming, and to select the traces that have to be delivered to the forensic service (human or animal blood). The authors have collected blood from crime scene, adsorbed it on a filter paper, and air-dried it, before extracting and amplifying it. The experiments showed a great stability of DNA up to 72h of storage in a buffer solution and showed a high sensibility of the method.

2.3.8. Thermal paper

Thermal paper has always been a problematic substrate for latent mark development because of the interactions between the paper's chemical components and the solvents used in chemical development reagents, leading to undesired blackening of the paper. Some researches have been conducted to optimize the existing techniques (198), to find new methods with reduced background darkening (199), or to reverse the blackening of the paper (200, 201). The HOSDB showed that DMAC was definitely not a good reagent for thermal papers (202).

The effectiveness of low-heat application for the development of latent fingermarks on thermal paper has been studied by Wakefield & Armitage, with the focus put on the factors that affect the development process (198). This article is cited as being the first to report and study this well-known technique. The main factors affecting the quality and extent of development using this technique were found to be the paper composition and the hair dryer brand.

The chemical fuming has also been evaluated as a potential technique to develop latent fingermarks on thermal papers (199). Nine chemicals (*i.e.*, acetone, ethyl acetate, acetic acid, ethanol, methanol, iso-propyl alcohol, hydrochloric acid, HFE-7100 and n-hexane) were tried, and the effectiveness between chemical fuming and ninhydrin (in HFR-711 PA) was compared. The fuming process consists in adding 20ml of a chemical in a Petri dish, while suspending the thermal paper above with the thermal surface facing down. The development time was no more than 20 seconds. Acetic acid proved to be the best chemical with 100% recovered fingermarks on one week/one month aged fingermarks and 95% for four months ones, compared to ~60% for ninhydrin. It should be noted that acetone, ethyl acetate, ethanol and iso-propyl alcohol led to white on black fingermarks, whereas hydrochloric acid, methanol and acetic acid lead to black fingermarks on white paper. The fuming process using acetic acid did not affect fingerprint development on nonthermal surface. One of the disadvantages of the method is the treatment of large exhibits.

The HOSDB conducted a study on DMAC to test its efficiency on thermal papers (202). First, they showed that DMAC does not react with urea as generally assumed, but with amino acids. Second, DMAC was compared with ninhydrin and DFO using ethanol pre-dip to remove thermal printing. The results showed that DMAC is significantly poorer than DFO and ninhydrin, and is thus not recommended for operational use.

Two articles proposed efficient techniques to discolour the background of blackened thermal papers after treatment with wet ninhydrin or DFO (petroleum ether and acetone as carriers). Siegel proposed to use cellophane tapes covering the entire receipt (201). The clearing occurs within a few hours to a few days and the item can be retreat by steam to visualize any latent marks. The Frosted Duck Matte Finish Invisible Tape showed to be the best. The results are not permanent and the latent mark will eventually dissolve over a period of time. Schwarz & Klenke proposed a secondary treatment using nitrogenous organic compounds to reverse the formation of dyed molecules (200). Best results were obtained with oenantholactam, 1-octyl-2-pyrrolidone, 1-cyclohexyl-pyrrolidone, and 4-pyrrolidone-pyridine dissolved in petroleum ether to obtain a 100mM concentration. The blackened samples were dipped in such a solution for a few seconds. The whitening started during the dipping and persisted for a week or for months, according to the thermal paper.

2.3.9. Tapes/Adhesives

Most of the articles related to the tapes and adhesives problematic were focused on the optimization of sequences and existing techniques (203-205). Three new reagents were proposed by the HOSDB (156) and compared to existing ones in laboratory trials (206).

Eight techniques were tested on five brands of electrical tape with both fresh and aged (35 days old) latent marks (204). The sequence that proved to be successful on the adhesive side of all tapes tested involved cyanoacrylate fuming and application of a fluorescent stain (Basic Yellow 40 / Basic Red 28), followed by white powder (TiO_2) suspension and finally gentian violet with a transfer of developed marks if necessary. Latent fingermarks on the nonadhesive side were also successfully developed with cyanoacrylate and the fluorescent stain.

Titanium dioxide (TiO_2) is a common paint pigment that can be used to develop latent marks from a variety of surfaces, including adhesives. It can produce a useful contrast on dark and transparent electrical and duct tapes. TiO_2, in a mixture of Kodak Photo-Flo 200 and water, works as a white small particle reagent (SPR-W) and can recover usable marks by direct application to the surface.

Williams & Elliott evaluated five methods of applying SPR-W (spraying, immersion, dipping, pasting, and pouring) under four different scenarios (205). The method that was the most effective on electrical and duct tape is submersion. A mixture of the reagent (aqueous TiO_2 or commercial Sirchie's SPR-W) with Kodak Photo-Flo can improve the results dramatically.

Brzozowski *et al.* tested three different reagents to develop fingermarks on the sticky side of adhesive tapes, that is, SSP, Wetwop® and Gentian violet with/without phenol (203). Wetwop® appeared to be the most universal reagent, giving good results on every kind of the six tested adhesives, with both fresh and old fingermarks. The other methods were limited, particularly with the acrylate layer of adhesives. If necessary, SSP can be used on rubber-based adhesives with good results.

Recently, the HOSDB proposed three new techniques for developing fingermarks on adhesive surfaces: Black powder suspension (BPS), White powder suspension (WPS), Basic Violet 3 (BV3) (156). BV3 is formulated without the use of phenol and is thus safer than the gentian violet, recommended to date. In laboratory trials, these three techniques showed similar effectiveness to the techniques currently recommended, if used appropriately. For this study, the adhesives have been categorised in two types: "rubber-based" or "acrylic-based". The majority of tapes fall into the "rubber-based" category. The adhesive side may be treated with either the powder suspensions or superglued and dyed with basic yellow 40. A small minority of tapes fall into the "acrylic-based" category. They can be most easily distinguished by heavy staining with powder suspensions or by IR spectroscopy. These tapes must be treated with BV3. For masking tapes, the most effective technique on the non-adhesive side is VMD, or superglue followed by black powder or black magnetic powder (less effective than VMD). The adhesive side has to be tested with powder suspension: if "rubber-based", the adhesive should be treated with BPS, if "acrylic-based": physical developer is recommended. The HOSDB also concluded that the BPS was the only technique to produce results on "Sainsbury's" greaseproof paper, used as drugs wraps by some criminals (206)]. For a standard greaseproof paper, the best technique was VMD (far more efficient than DFO and ninhydrin).

2.3.10. Detection of marks on items collected from arson scenes

> The development of latent fingermarks on soot-covered items that have been recovered from arson scenes has proven to be very difficult. The chance of recovering fingermarks from such soot-covered items can be virtually nil, due to the harsh conditions they have been confronted to. A research however demonstrated that almost one of five items recovered from fire scenes yielded fingerprint ridge detail following normal development treatments (207). All the articles found in the literature and related to arson scenes consisted in comparing the existing techniques to establish the best sequence of detection (141, 208-210).

Wyllie studied various techniques to recover fingermarks from arson scenes (210). His conclusions were: (1) the 2% sulphosalicylic acid pre-bath (to fix the latent mark) followed by a 0.1M NaOH soot removal solution has proved to be effective on non-porous surfaces, especially when the soot is of a “greasy” consistency, (2) no notable difference was observed between the aluminium powders and cyanoacrylate fuming + BY40 dye as enhancement techniques on non-porous surfaces (both produced approximately a 50% success rate) , and (3) the horizontal distance of the item from the origin of the fire does have an effect on the success of fingermark recovery (the greater the distance, the greater the probability of fingermark recovery); the height also does play a role (the higher the item is compared to the floor appears to decrease the chance of a successful fingermark recovery).

Another study aimed to expand the scope of previous research by assessing the effectiveness of soot-removal technique on glass from petrol-bomb debris using methods of 1% and 2% NaOH solutions, ultrasonic bath and vacuum suction (209). Favourable results were found to varying degrees using each of the soot-removal methods with the 1% and 2% NaOH wash solutions, being the most useful. This study also showed that recovery of fingermarks in blood from beneath soot using the 2% NaOH solution was possible.

The HOSDB highlighted the conditions in which fingermarks are likely to survive on arson scenes, the best processes for removing smoke and soot from contaminated surfaces, and the best processes for subsequent fingermark development (208). A range of soot removal techniques has been investigated and different sequences were proposed, according to the surface to be cleaned, with the following advices: (1) the techniques using water should be used as a last resort, excepting for techniques that remove soot AND develop marks at the same time (*e.g.*, Black or White powder suspension, SPR); (2) NaOH is potentially destructive to DNA and should not be used if DNA recovery is to be attempted at a later stage; (3) many of the techniques continued to function to some extent for exposure temperatures up to 200°C, although their effectiveness was reduced; (4) the following techniques were not recommended: rehumidification (destroy dry residues), aluminium powder (less effective than black magnetic powder), leuco crystal violet (less sensitive than acid yellow 7). It is also highlighted that fingermarks in blood can survive exposure to 100°C for at least eight hours without affecting the effectiveness of the blood reagents (141).

2.4. Fingermark detection and DNA or biological fluid analysis

This section covers the critical factors towards obtaining DNA profiles from fingermarks or other traces, at the exception of bloodmarks which have been cited in a previous section. An extensive review of trace DNA analysis during an investigation was proposed by Raymond et al. (211). The rest of the contributions were dedicated to the compatibility between the fingermark detection techniques and the possibility to obtain DNA profiles (212-214) and the DNA transfer to bedding (215). Some authors also warned about the possible contamination of powder brushes by DNA (216, 217).

In a case report, Schulz *et al.* described the possibility to use ninhydrin-developed fingermarks as a DNA source for STR typing (212). In 2006, Leemans *et al.* evaluated different methods for recovering fingermarks from objects (glass slides) and different DNA storage and extraction techniques (213). They observed that powdering (white and black) and cyanoacrylate fuming (with basic yellow staining) did not interfere with the DNA amplification process. Similarly, Prinz *et al.* developed methodologies to maximize the STR DNA typing success from touched objects (214). Another contribution examined the potential transfer of trace DNA to bedding by normal contact, when an individual sleeps in a bed (215). The results indicated that the DNA profile of an individual can be obtained from bedding after one night of sleeping in a bed. Since mixed DNA profiles can be obtained from trace DNA on bedding, caution should be exercised when drawing conclusions from DNA profiling results obtained from such samples.

Van Oorschot *et al.* warned practitioners using fingerprint brushes on potential DNA transfers during powdering (216). Squirrel-hair fingerprint brushes exposed to specific sets of saliva stains and brushes used in routine casework were tested for their ability to collect and transfer DNA containing material using standard DNA extraction procedures and AmpF/STR Profiler Plus amplification and typing procedures. The tests showed that the risk of transferring DNA during powdering and having a detrimental impact on the analysis increases if the examiner powders over either biological stains (blood or saliva) or very fresh prints and uses more sensitive PCR amplification and typing procedures. The authors advocate caution when powdering marks from which DNA may also be collected and provide options to limit the risk of transferred DNA contamination while powdering. In 2006, Proff *et al.* observed that DNA could be observed in partial or full profiles on 86% of tested brushes (used at crime scenes and coming from different European countries) (217). To avoid secondary transfer, the authors recommended to change the brushes after investigating large crime scenes, or to develop decontamination procedures for brushes.

3. Barefoot impressions

The method to conduct barefoot morphology comparison and the associated cases has been well described recently (218). In a previous paper, Kennedy *et al.* showed that the probability that a person leaves a footprint (barefoot impression) indistinguishable from another was less than 10^{-8}. In this new contribution, the authors presented the advances they made in their research (219). After having established a rigorous mathematical framework, they repeated the previous research with an expanded population sample size. These improvements led to a new estimated probability of 7.88 10^{-10}. A study of 1040 adult male Gujjars from North India detailed the relative frequencies of phalange marks, pits, cracks, abnormal horizontal ridge and flatfoot character including bilateral variations (220). On a population of Rajputs of Himachal Pradesh – a North Indian endogamous group – foot length has shown to be an efficient predicting value to estimate the stature of an individual (221). On the same Gujjars population, Krishan confirmed the quality of the correlation and published the regression equations allowing assessing, respectively from right and left foot impression, the stature of the individual involved in its production (222).

We came across a few publications in relation to footprints outside the forensic arena but are very relevant in our opinion. The angle of gait (somewhat specific to the walking individual) has been estimated from footprints (223). Extension to the base of gait is also proposed and compared to the results from static footprints with the data acquired dynamically (224). The Cavanagh's arch index (AI) measurement has been compared between estimates obtained from footprints and from data coming from pressure platforms (225). Differences in AI estimations have been observed between conventional inked standard and a capacitance-mat pressure platform. AI is used by podiatrists to classify individual foot types. The use of multiple metrics (among them AI) to classify the footprints of schoolchildren is reported by Nikolaidou and Boudolos (226).

4. Ear marks

The paper by Broeders highlights in this field (and draw parallels with others), the difficulties to show in a transparent manner the strength of such evidence (4). The new DNA results in the case against Dallagher led commentator to view earprint comparison with a sceptical eye (227).

Preliminary results regarding the automatic recognition of earprints are presented by Rutty *et al.*, but overall remained at the proof of concept stage (228).

The initiative of the consortium FearID (www.fearid.com) was to investigate and provide objective measures in the field. Their results have been published during this reviewing period. The research was conducted on a large database of earprints (over 1200 donors). The issues in relation with the classification have been covered in (229). The detailed study of inter and intra-individual variation in earprints led to the publication of a PhD thesis (230). That study included the systematic assessment of earprints from twins. The issues in relation with marks (that could be partial and blurred) have not been tackled.

The definition of the feature vector relied on the annotation of earprint images by skilled operators. Alberink *et al.* studied the effect of the operator (231) and highlighted that the between operators variation was causing a large detrimental effect on the efficiency of the system. The efficiency of the developed recognition system has been tested (232). The features are extracted from a "polyline" superimposed on the earprint by an operator. The matching is obtained using Vector Template Machine as described in http://forensic.to/fearid/VTMfinal.doc. For print to print comparison it was shown that for 90% of all query searches the best hit is in the top 0.1% of the list. The results become less favourable (equal error rate of 9%) for mark to print comparisons.

Abbas & Rutty gave important data regarding the distribution of ear piercing (number, location) according to genders (233).

Recent research in ear biometrics is worth citing. It is expected that such research will have a drastic impact on the forensic research in earmarks in the years to come (234-238).

5. Lipmarks

Identification using lipmarks was first performed in the 1950s and was the subject of much research in the 1960s and 70s, leading to the acceptance of this technique as evidence in some criminal justice systems (to our knowledge in Poland and Japan). Authors have proposed new reagents (239) or techniques allowing to detect lipmarks (contaminated with lipstick) on various surfaces (240, 241), to study the evolution with time of lip prints from cadavers (242) or the specific features left by dedicated activities (243). The possibility to obtain DNA from latent lipmarks has also been studied (244).

Lysochromes are particularly useful reagents to develop latent lipmarks. However, if the mark is left on coloured or multicoloured surfaces, contrast problems may appear between the reagent and the surface. Nile red (powder or dissolved in ethanol) was proposed as a highly efficient luminescent developer for latent lipmarks, especially very old ones (over 1 year) on various surfaces (239), except for human skin on which is appeared it was poorly effective (241). Navarro *et al.* proposed to determine the effectiveness of several reagents for developing invisible lipmarks on corpse's skin (240). Two different lipsticks were used for this study: a standard protective and a long-lasting one. Preliminary results showed that, under the described experimental conditions, the reagents used (Sudan III, Oil Red O and Sudan Black) were effective for obtaining recent latent lipmarks on corpse's skin. The reagents were applied under their powder form and were thus brushed on the skin, then washed with water, and finally swabbed for DNA profiling. The authors did not give any results about the DNA profiling. Recently, the same team announced that the REDescent Fluorescent Latent Prints Powder is effective for obtaining fresh invisible lipstick-contaminated lipmark on human skin of cadavers (241). Finally, an attempt to obtain DNA from latent lipmarks developed with Sudan Black on porous surfaces (paper handkerchiefs) was successfully performed by Castello *et al.* (244).

Utsuno *et al.* proposed to clarify characteristics of lip prints from cadavers with various causes of death (including drowning and hanging) and to determine the effects of fixation on post mortem changes in lip impressions (242). Lip impressions were taken from 20 cadavers on two occasions, that is, less than 24h from the time of death and 48h after fixation in 10% formalin and maintained at 21°C. No significant enlargement or shrinkage occurred after fixation, and an identification rate of 30% has been obtained. The authors also observed that if the mouth is closed, relatively well-defined groove were obtained. The authors planned to investigate lip prints from cadavers exposed to natural environment. The specific features acquired when playing wind instruments have been presented in a Polish study (243).

6. Bitemarks

The discussion on the validity and reliability of scientific techniques in court under *Daubert* have brought many previously accepted methods to forensic investigation under closer inspection. Bitemark evidence is no exception. Several papers are dealing with this particular issue (245-248). The development of new software or methods able to represent or compare bitemarks and dental prints in 3D has also been the subject of many contributions (249-253). Finally, human (254-256) and animal (257, 258) bitemarks were analyzed (case reports or in a research context), and the results of a large survey have been presented (259).

BITEMARK IN COURT – If bitemark analysis is to continue to play a role in the judicial process, there is an urgent need for high quality studies that meet the levels of forensic and scientific scrutiny applied to other disciplines within the criminal justice system. Studies are required to determine not that the human dentition is unique, but how this asserted uniqueness is represented on the bitemark on human skin and other substrates. The estimation error rates associated with bitemark comparisons is required. Reviews of the literature on bitemark analysis revealed that the vast majority of published works are case reports, and that very little primary literature exists (15, 248). However the research activity in this area is beginning to address the fundamental issues of the discipline. Pretty proposed a review of the studies that have assessed aspects of bitemark analysis including the crucial issue of the uniqueness of the human dentition; the application of transparent overlays and the application of statistical probabilities in bitemark conclusions (246). Another paper focused on the author's participation as a Defence expert over the last seven years in over 50 bitemark prosecutions and judicial appeals (245). Numerous efforts have also been made to develop a consistent manner to describe bite injuries. Some have been related to the type of injury, others to the manner in which it was caused or simply its anatomical location. A novel index, relating severity to forensic significance, was developed by Pretty (247). A text version and accompanying visual index were produced and distributed (via the web) to three groups (odontologists, forensic pathologists, and police officers) and demonstrated a high level of intra-operator and inter-operator reliability, particularly in the police officer group. The index showed to be promising as a universal means of describing bite injuries between professionals concerned with their detection and analysis.

DIGITAL ANALYSIS – DentalPrint is a new software that generates different comparison overlays from 3D dental cast images depending on the pressure of the bite or the distortion caused by victim-biter interaction (251). The procedure for generating comparison overlays is entirely automatic to avoid observer bias, and the software makes it impossible for third parties to manipulate or alter the 3D images. Validation studies of the new DentalPrint software were carried out to ensure that this method is supported by scientific evidence to promote justice (253). The results indicated that DentalPrint is a useful, accurate tool for forensic purposes, although further research on the comparison process is needed to enhance the validity of bite mark analysis. The reliability of two methods used to produce computer-generated bitemark overlays with Adobe Photoshop were compared (250): the first one (routinely used in North America) is based on the use of "magic wand tool" over the biting edge and the second one (predominantly used in Europe) on the different contrast levels found in the cast image. The assessment of the area measurements showed significant variances in the examiner variable for both techniques resulting in low reliability coefficients. Conversely, the results for the positional measurements showed no significant differences in the variances between examiners with exceptionally high reliability coefficients. It was concluded that both techniques were reliable methods to produce bitemark overlays in assessing tooth position. In another study, the applicability of holography in the 3D recording of recording objects such as skulls and mandibulae, and the accuracy of the reconstructed 3D images, were examined (249). The results suggested that the virtual images produced by holography could be useful as a substitute for the original object in forensic identification. Two superimposition systems using holographic images were examined: the 2D-3D (the raw 3D virtual holographic image is directly superimposed onto the photograph on the LCD monitor) and video superimposition systems (the virtual holographic image is converted to a 2D image, which was then superimposed on the digitized photographic image). The authors found that holography seemed to perform comparably to the computer graphic systems. The discrepancy of superimposition for the video superimposition system was smaller than using a 2D-3D system. The real holographic image was not utilized for superimposition due to some discrepancies that could remain in actual superimposition. A study also investigated the suitability of two different methods for identification of bitemarks by digital analysis: 2D polyline and painting under Photoshop (252). In the 2D polyline method, fixed points were chosen on the tips of the canines and a straight line was drawn between the two fixed points in the arch, lines and angles are also calculated. In the painting method, the identification is based on canine-to-canine distance, tooth width and the thickness, and rotational value of each tooth. The results showed that both methods were applicable. However, the 2D polyline method was more convenient to use and gave prompt computer-read results, whereas the painting method depended on the visual reading of the operator.

HUMAN BITEMARKS - Anterior teeth within the human dentition have a specific numerical rotation value. It means that bitemarks show an array of angled indentations, abrasions, microlacerations, and contusions, and represent the incisal surfaces of the suspect's dentition reflecting the rotation values of the teeth in the dental arch. Bernitz *et al.* described a method for capturing and analyzing anterior dental rotations (254). In the absence of a large number of incisal patterns present in a bitemark, a single but heavily weighted tooth rotation could be of equal discriminatory potential obtained from several common rotation values. As mentioned by the authors, this article constituted a groundwork and should be followed by further investigations. The aim was to make the frequency of dental rotations no more based on examiners' experience only. In a short report, Hunt described injuries that appeared like bitemarks but that were not (256). Dixon described the possibility to use transferred bacteria at the moment of the bite to use them as evidence, since they are genotypically highly diverse among individuals (255).

ANIMAL BITES - Insect bites were shown to present an unusual symmetrical pattern on the right arm of a victim (257). Another study compared the jaw shapes patterns of 486 specimens (wild and domestic animals) to assist investigators in their analysis of animal bite marks (258).

CASE REPORT - A survey has been sent to 1100 forensic dentists in 26 countries (52 forensic odontologists answered) about the aetiology, anatomic location, victim demographics and legal disposition of bitemark cases (259). The data of 259 bitemark cases, including 778 individual bitemarks, were collected and the results presented: while bitemarks were found on all anatomic regions of the body some sites are significantly more likely to receive bites, and the frequency that an area is bitten may vary with the type of crime (homicide, followed by sexual assault and child abuse). Sex and age of the victim may also impact the resulting location and frequency of bites, as females were victims more often than males.

7. Case studies

Latent marks development using ninhydrin combined with DNA profiling on anonymous letters has allowed to identify the author of anonymous letters (260).

Authors have considered the papillary crest impressions detected on a gun to study the dynamic of a gun shot murder in order to realize how the event took place. The latent fingermarks were detected using a xenon source light, and cyanoacrylate fuming (261).

Two seizures of counterfeit 100 US$ bills related to the same indicative number were submitted for processing of latent fingermarks. On one group, identifiable marks could be detected by the routine application of amino acid reagents (DFO, followed by ninhydrin). For the second case, this sequence provided poor results, even on deliberately deposited prints. Fingermarks could be revealed, however, using cyanoacrylate fuming followed by magnetic powder. Comprehensive paper analysis showed that banknotes from both seizures differed remarkably by chemical compositions as well as paper macroscopic properties. The difference in surface free energy (related to surface tension) of the banknotes in the two groups seemed to be the major factor responsible from the great variance in fingermark detectability. Consequently, the authors suggest careful investigation of the paper properties prior to fingerprint processing (262).

Authors reported the identification of a culprit from DNA profiles obtained from saliva and sweat traces detected by Crimescope® and linked to two different robberies (263).

The San Bernadino Police Department reported a case linked to the Authentiprint label that is used to place an inkless fingerprint on checks and other documents. After a year, the fingerprint may become completely faded and the area blank. The fingerprint can however been viewed again by fluorescence, using a 570nm light source combined with a red barrier filter (264).

An infant-to adult footprint identification is presented in Sinclair and Fox. To establish US citizenship, footprints obtained in 1979 in the United States were compared and identified against the footprints from the applicant taken in 2004 (265).

8. Miscellaneous

IRRADIATION - The use of the postal system as a mean of delivering anthrax spores via several contaminated envelopes, in the late 2001, has led to the selective irradiation of mail and to some unexpected complications. Indeed, the high doses of radiation required to destroy biological agents were sufficient to induce damage to other materials present in the envelope. Ramotowski & Regen focused on the impact of the irradiation process on the ability to visualize latent marks (266). The results indicated that the irradiation process can have a detrimental effect on the success of certain visualization reagents and can cause physical damages to non-porous surfaces. For example, samples processed with DFO or ninhydrin on porous samples showed a noticeable decrease in both the initial colour and fluorescence intensity. Most of the samples treated with gentian violet did not develop ridge detail. In the samples that did develop detail, the intensity and clarity of the development was comparable between the control and irradiated samples. The effect can somewhat be beneficial: physical developer-treated samples showed an improvement of the results, as well as for the MMD.

WARFARE - The effect of exposure to chemical warfare agents and to decontaminating agents on the ability of the forensic identification specialist to recover latent fingermark evidence using common fingerprint development techniques was studied by Wilkinson *et al.* (267).

HUMAN SKIN - A review of personal experience, published accounts, interviews, case reports, and data collected from more than 4,000 student questionnaires pertaining to the recovery of latent marks from human skin is presented by Sampson & Sampson (268). It was determined from the surveys that there have been approximately 70 different methods (or variations) used to process human skin for mark evidences. The surface conditions of the body and the ambient environment (temperature and humidity) were discussed, and recommendations were presented to achieve optimum results. This article constitutes a guideline for the processing of human skin for latent marks and it is suggested that efforts to obtain latent marks from human skin are sporadic and should be increased. It should be noted that Yamashita answers to this article, through a letter to the editor, and raised the attention on the fact that the authors have not been very clear on their conclusions about the best techniques and experimental conclusions (269).

EXPLOSIVES - An initial test was conducted to determine whether undeveloped latent mark impressions would survive an explosion (270). Test marks were located on surfaces in a vehicle (on items) and on a vehicle's exterior door handles in which two types of explosives (Semtex and RDX/TNT mixture) were placed. Some surface areas were completely destroyed during the blasts. Only one very faint print was located on an exterior door handle using RUVIS. The authors encouraged further studies to be performed in this domain.

CARS - The HOSDB provided advices to detect fingermarks on cars (135): the smooth surfaces should be powdered at the scene; the textures surfaces that are unsuitable for powdering but suitable for treatment with superglue and that can be removed should be taken back to the laboratory and treated there; any surfaces that are unsuitable for powdering, are suitable for treatment with superglue but cannot be removed can be treated with superglue at the scene using a system such as SUPERfume®. Finally, aluminium powder was shown to be more effective on car windows than superglue. It has also been observed that some thieves now spray stolen cars with WD40 to prevent the police to recover fingermarks (206). A small experiment showed that solvent black 3 and SPR stain the WD40. Black powder suspension appeared not to adhere to WD40 and allowed thus to develop fingermarks.

GLOVES – Lounsbury & Thompson showed that vinyl gloves that are routinely used in crime scene processing do protect against hazards but are thus not effective against scene contamination (271). Indeed, if contaminated by human sweat, identifiable fingerprint patterns could be left on touched surfaces. This was not the case with nitrile or latex gloves, which left only unidentifiable marks. At this purpose, the development of fingermarks on gloves remains a tedious task. Some of the common methods for processing latex gloves are the use of ninhydrin, gentian violet, sudan black, Gellifters, and cyanoacrylate fuming followed with regular fingerprint powder, magnetic powder, or dye stain. Velders tested several methods on latex and vinyl gloves (272). On fresh fingermarks left on the internal side of the gloves, his conclusions were that all chemical or physical treatments gave bad or mediocre results, with the destruction of the glove for some. The best results on the latex and vinyl gloves were obtained with gloves that, with no previous chemical treatment, were processed with black Gellifters. Using this physical method, fingermarks can be lifted up to 10 days after the gloves have been worn, depending on the conditions at which they were kept. In the palm area of the tested gloves, no identifiable ridge detail was found, probably due to the friction between glove and hand during wearing. The author recommended this area for securing DNA evidence. Recently, Pleckaitis proposed a one-step process using Wetwop to develop latent prints on (and inside) latex gloves and nitrile gloves (273). Gloves that were worn from one minute to thirty minutes yielded more identifiable impressions that were located on the fingers. When gloves were worn for longer periods of time, the identifiable impressions were more likely to be located on the lower finger joints and palms and seldom on the fingers. The author also observed that cyanoacrylate fuming before Wetwop inhibit the process. Successful results for the detection of latent fingermarks on latex gloves have been reported using a ninhydrin heptane-based solution (274).

HISTORICAL FACTS - An examination of four Sumerian tablets from the Ur III period revealed epidermal ridge impressions that were made when the clay was in a plastic state. The location of the ridge impressions can assist the investigator in reconstructing possible positions in which the tablet was held when the impressions were formed (275). A newly discovered fingerprint in "The adoration of the Christ child" paint are making experts think that *Leonardo da Vinci* could be the author of the paint, and not *Fra Bartolomeo* as it is currently thought (276).

FRUITS - The procedure for developing latent fingermarks on fruits and vegetables has been studied by Singh *et al.* (277, 278). Powders (activated charcoal and lightning gray powder) applied with feather brushes were able to develop latent fingermarks with very high quality. The nature of the fruit/vegetable surface logically played a great role in the recovery (or not) of aged fingermarks. The iodine fuming method did not yield good results. It has to be noted that no attempt was made to fix the iodine developed fingermarks and that the procedure of fingermark recording was quite time consuming (lifting by clear adhesive tape, affixing on a white sheet of paper, and scanning). Iodine may thus have fainted during this procedure, but the authors did not discuss this fact. Polyray was also used to detect the latent fingermarks fruits and vegetables, by observing them using orange goggles. The authors observed that a grazed angle gave the best results to observe fingermarks. The best results in terms of clarity were obtained on apples and tomatoes.

SURFACES OF CD - Various methods have been tried to develop fingermarks on the writing surface of a CD and results are discussed with respect to their development as well as their effect on stored data and data retrieval (279).

GETTING PRINTS FROM CADAVERS – A report discusses the success by using the Mikrosil® casting method in obtaining exemplar prints from cadavers and also its advantages over other traditional methods (280). The recent mass disasters have triggered the publication of new guides to the recovery of prints from cadavers. The FBI published detailed information regarding the boiling techniques that have been used recently with success (281). A German group published in collaboration with the BKA a comprehensive booklet describing all methods and issues (notably the use of dermal prints and AFIS) associated with degraded prints (282).

9. References

(1) Brettell TA, Butler JM, Saferstein R. Forensic science. *Analytical Chemistry* 2005; 77**:** 3839-3860.

(2) Brettell TA, Butler JM, Almirall JR. Forensic science. *Analytical Chemistry* 2007; 79**:** 4365-4384.

(3) Rendle DF. Advances in chemistry applied to forensic science. *Chemical Society Reviews* 2005; 34**:** 1021-1030.

(4) Broeders APA. Of earprints, fingerprints, scent dogs, cot deaths and cognitive contamination - a brief look at the present state of play in the forensic arena. *Forensic Science International* 2006; 159 (2-3)**:** 148-157.

(5) Saks MJ, Koehler JJ. The coming paradigm shift in forensic identification science. *Science* 2005; 309 (5 August 2005)**:** 892-895.

(6) Widmaier G (Ed.). *Münchener Anwalts Handbuch Strafverteidigung.* München, C. H. Beck Verlag: 2006.

(7) Faigman DL, Kaye DH, Saks MJ, Sanders J, Cheng EK (Eds.). *Modern scientific evidence: The law and science of expert testimony.* Eagan, MN, Thompson/West Publishing Co.: 2007.

(8) Bowman V (Ed.). *Manual of fingerprint development techniques.* Sandridge, Home Office Scientific Research and Development Branch: 2004.

(9) Stoilovic M, Lennard C. *Fingerprint detection and enhancement.* Canberra, Australian Federal Police: 2006.

(10) Triplett M. *Fingerprint dictionary.* Bellevue, WA, Two Rings Publishing: 2006.

(11) McKie I, Russell M. *Shirley McKie: The price of innocence.* Edinburgh, Birlinn Ltd.: 2007.

(12) McKie IAJ. Fingerprint in print – an opportunity missed? *CACNews* 2005 (2)**:** 10 & 19-20.

(13) Leo W. *Fingerprint identification.* San Clemente, CA, Law Tech Custom Publishing Inc.: 2004.

(14) Coppock CA. *Contrast - an investigator's basis reference guide to fingerprint identification concepts.* Springfield, Ill., Charles C. Thomas: 2007.

(15) Dorion BJ. *Bitemark evidence.* New York, Marcel Dekker: 2005.

(16) Komarinski P. *Automated fingerprint identification systems (AFIS).* New York, Elsevier Academic Press: 2005.

(17) Ross A, Nandakumar K, Jain AK. *Handbook of multibiometrics.* New York, Springer Verlag: 2006.

(18) Brown JP. A latent print examiner's guide to IAFIS. *Journal of Forensic Identification* 2007; 57 (4)**:** 539-549.

(19) Edgubov LG. Some facts about coordinate characteristics in science of fingerprints. *Fingerprint Whorld* 2006; 32 (124)**:** 75-85.

(20) Jain AK, Yi C, Demirkus M. Pores and ridges: High-resolution fingerprint matching using level 3 features. *Pattern Analysis and Machine Intelligence, IEEE Transactions on* 2007; 29 (1)**:** 15-27.

(21) Wein LM, Baveja M. Using fingerprint image quality to improve the identification performance of the U.S. Visitor and immigrant status indicator technology program. *Proceedings of the National Academy of Sciences of the USA* 2005; 102 (21)**:** 7772-7775.

(22) Yen R, Guzman J. Fingerprint image quality measurement algorithm. *Journal of Forensic Identification* 2007; 57 (2)**:** 274-287.

(23) Interpol (2004) Interpol European expert group on fingerprint identification II - IEEGFI II. Part 2: Detailing the method using common terminology and through the definition and application of shared principles. Lyon, Interpol.

(24) Sodhi GS, Kaur J. The forgotten Indian pioneers of fingerprint science. *Current Science* 2005; 88 (1)**:** 185-191.

(25) Buras D. Use of fingerprint examination by the state police in the "2nd polish republic". *Problemy Kryminalistyki* 2004 (246)**:** 56-61.

(26) Smrz MA, Burmeister SG, Einseln A, Fisher CL, Fram R, Stacey RB*, et al.* Review of FBI latent print unit processes and recommendations to improve practices and quality. *Journal of Forensic Identification* 2006; 56 (3)**:** 402-434.

(27) Stacey RB. A report on the erroneous fingerprint individualization in the Madrid train bombing case. *Journal of Forensic Identification* 2004; 54 (6)**:** 706-718.

(28) Budowle B, Buscaglia J, Schwartz Perlman R. Review of the scientific basis for friction ridge skin comparisons as a means of identification: Committee findings and recommendations. *Forensic Science Communications* 2006; 8 (1)**:** http://www.fbi.gov/hq/lab/fsc/current/research/2006_2001_research2002.htm.

(29) Kent T. Fingerprint identification – time to move forward. *Fingerprint Whorld* 2006; 32 (125)**:** 149-154.

(30) United States Department of Justice, Office of the Inspector General - Oversight and Review Division. *A review of the FBI's handling of the Brandon Mayfield case (unclassified and redacted).* Washington DC: 2006.

(31) Gysin R. Der Fingerabdruck steht unter Verdacht. *Plädoyer* 2005; issue 6**:** 11-13.

(32) Rudin N, Inman K. Fingerprints in print, the sequel. *CACNews* 2005 (2)**:** 6-8.

(33) Commonwealth v Terry L. Patterson (2005), United States District Supreme Court of Massachusetts, Sjc-09478.

(34) Steele Lisa J. for NACDL & others. Amicus brief in Commonwealth v Terry L. Patterson. *SJC-09478, Supreme Judicial Court of Massachusetts* 2005.

(35) Siegel DM, Fisher SZ, Givelber D. Amicus brief in Commonwealth v Terry L. Patterson. *SJC-09478, Supreme Judicial Court of Massachusetts* 2005.

(36) Saltzman J. Massachusetts bars simultaneous prints at trial. *The Boston Globe* 2005: December 28, 2005.

(37) Black JP. Pilot study: The application of ACE-V to simultaneous (cluster) impressions. *Journal of Forensic Identification* 2006; 56 (6)**:** 933-971.

(38) State of New Hampshire v. Richard Langill (2007), Rockingham, SS Superior Court, 05-s-1129.

(39) Zabell SL. Fingerprint evidence. *Journal of Law and Policy* 2005; 13 (1)**:** 143-179.

(40) Harmon R, Budowle B, Langenburg G, Houck MM. Letters: Questions about forensic science (with response). *Science* 2006; 311 (3 February)**:** 607-610.

(41) Cole SA, Dioso R. Law and the lab. *The Wall Street Journal* 2005: Friday, May 13, 2005.

(42) Cole SA. More than zero: Accounting for error in latent fingerprint identification. *The Journal of Criminal Law and Criminology* 2005; 95 (3)**:** 985-1078.

(43) Cole SA. The prevalence and potential causes of wrongful conviction by fingerprint evidence. *Golden Gate University Law Review* 2006; 37**:** 39-105.

(44) Cole SA. The myth of fingerprints: The legacy of forensic fingerprinting and arrestee databases. *GeneWatch* 2006; 19 (6)**:** 3-6.

(45) Cole SA. Is fingerprint identification valid? Rhetorics of reliability in fingerprint proponents' discourse. *Law and Policy* 2006; 28 (1)**:** 109-135.

(46) Ashbaugh DR, Houck MM. Fingerprints and admissibility: Friction ridges and science. *Fingerprint Whorld* 2006; 32 (123)**:** 21-42.

(47) Editor. Fingerprints: In facts. *Scientific Sleuthing Review* 2005; 29 (1)**:** 8.

(48) Triplett M, Cooney L. The etiology of ACE-V and its proper use: An exploration of the relationship between ACE-V and the scientific method of hypothesis testing. *Journal of Forensic Identification* 2006; 56 (3)**:** 345-355.

(49) Gray L. ACE to elimination. *Fingerprint Whorld* 2005; 31 (120)**:** 75-81.

(50) McKasson S. Re: Proportional analysis: The science of comparison. *Journal of Forensic Identification* 2004; 54 (3)**:** 273-274.

(51) Maceo AV. The basis for the uniqueness and persistence of scars in the friction ridge skin. *Fingerprint Whorld* 2005; 31 (121)**:** 147-161.

(52) Siegel S. The formation of friction ridge skin. *Lone Star Forensic Journal* 2005; 59 (3)**:** 7-21.

(53) Kücken M. *On the formation of fingerprints*. PhD, Graduate Interdisciplinary Program in Applied Mathematics, The University of Arizona, Tucson: 2004.

(54) Kücken M, Newell AC. A model for fingerprint formation. *Europhysics Letters* 2004; 68 (1)**:** 141-146.

(55) Kücken M, Newell AC. Fingerprint formation. *Journal of Theoretical Biology* 2005; 235 (1)**:** 71-83.

(56) Kücken M. Models for fingerprint pattern formation. *Forensic Science International* 2007; In Press, Corrected Proof.

(57) Dror I. Experts and technology: Do's & don'ts. *Biometric Technology Today* 2005; 13 (9)**:** 7-9.

(58) Dror IE, Péron A, Hind S-L, Charlton D. When emotions get to the better of us: The effect of contextual top-down processing on matching fingerprints. *Applied Cognitive Psychology* 2005; 19 (6)**:** 799-809.

(59) Dror IE, Charlton D. Why experts make errors. *Journal of Forensic Identification* 2006; 56 (4)**:** 600-616.

(60) Dror IE, Charlton D, Péron AE. Contextual information renders experts vulnerable to making erroneous identifications. *Forensic Science International* 2006; 156**:** 74-78.

(61) Schiffer B, Champod C. The potential (negative) influence of observational biases at the analysis stage of fingermark individualisation. *Forensic Science International* 2007; 167 (2-3)**:** 116-120.

(62) Kerstholt JH, Paashuis R, Sjerps M. Shoe print examinations: Effects of expectation, complexity and experience. *Forensic Science International* 2007; 165 (1)**:** 30-34.

(63) Byrd JS. Confirmation bias, ethics, and mistakes in forensics. *Journal of Forensic Identification* 2006; 56 (4)**:** 511-525.

(64) Langenburg G. Pilot study: A statistical analysis of the ACE-V methodology - analysis stage. *Journal of Forensic Identification* 2004; 54 (1)**:** 64-79.

(65) Busey TA, Vanderkolk JR. Behavioral and electrophysiological evidence for configural processing in fingerprint experts. *Vision Research* 2005; 45 (4)**:** 431-448.

(66) Neumann C, Champod C, Puch-Solis R, Meuwly D, Egli N, Anthonioz A*, et al.* Computation of likelihood ratios in fingerprint identification for configurations of three minutiae. *Journal of Forensic Sciences* 2006; 51 (6)**:** 1255-1266.

(67) Neumann C, Champod C, Puch-Solis R, Egli N, Anthonioz A, Bromage-Griffiths A. Computation of likelihood ratios in fingerprint identification for configurations of any number of minutiae. *Journal of Forensic Sciences* 2007; 52 (1)**:** 54-64.

(68) Egli NM, Champod C, Margot P. Evidence evaluation in fingerprint comparison and automated fingerprint identification systems--modelling within finger variability. *Forensic Science International* 2007; 167 (2-3)**:** 189-195.

(69) Seweryn P. Frequency of minutiae on left and right hand index fingers [in polish]. *Problemy Kryminalistyki* 2005 (247)**:** 40-46.

(70) Gutiérrez E, Galera V, Martínez JM, Alonso C. Biological variability of the minutiae in the fingerprints of a sample of the Spanish population. *Forensic Science International* 2007; In Press, Corrected Proof.

(71) Meuwly D. Forensic individualisation from biometric data. *Science & Justice* 2007; 46 (4)**:** 205-213.

(72) Wertheim K, Langenburg G, Moenssens A. A report of latent print examiner accuracy during comparison training exercises. *Journal of Forensic Identification* 2006; 56 (1)**:** 55-93.

(73) Haber L, Haber RN. Letter to the editor - a report of latent print examine accuracy during comparison training exercises. *Journal of Forensic Identification* 2006; 56 (4)**:** 493-510.

(74) Czarnecki ER. Laterally inverted fingerprints. *Journal of Forensic Identification* 2005; 55 (6)**:** 702-706.

(75) Kaur R, Garg RK. Determination of gender from fingerprints based on the number of ridges in a defined area. *Fingerprint Whorld* 2006; 32 (125)**:** 155-159.

(76) Singh I, Chattopadhyay PK, Garg RK. Determination of the hand from single digit fingerprint: A study of whorls. *Forensic Science International* 2005; 152 (2-3)**:** 205-208.

(77) Swofford HJ. Fingerprint patterns: A study on the finger and ethnicity prioritized order of occurence. *Journal of Forensic Identification* 2005; 55 (4)**:** 480-488.

(78) Doak R. Dominant deltas - a concept. *Fingerprint Whorld* 2004; 30 (117)**:** 118-123.

(79) Voos-de-Haan P. Physics and fingerprints. *Contemporary Physics* 2006; 47 (4)**:** 209-230.

(80) Archer NE, Charles Y, Elliott JA, Jickells S. Changes in the lipid composition of latent fingerprint residue with time after deposition on a surface. *Forensic Science International* 2005; 154 (2-3)**:** 224-239.

(81) Mountfort KA, Bronstein H, Archer N, Jickells SM. Identification of oxidation products of squalene in solution and in latent fingerprints by ESI-MS and LC/APCI-MS. *Analytical Chemistry* 2007; 79**:** 2650-2657.

(82) Richmond-Aylor A, Bell S, Callery P, Morris K. Thermal degradation analysis of amino acids in fingerprint residue by pyrolysis GC-MS to develop new latent fingerprint developing reagents. *Journal of Forensic Sciences* 2007; 52 (2)**:** 380-382.

(83) Pragst F, Auwärter V, Kiessling B, Dyes C. Wipe-test and patch-test for alcohol misuse based on the concentration ratio of fatty acid ethyl esters and squalene CFAEE/CSQ in skin surface lipids. *Forensic Science International* 2004; 143 (2-3)**:** 77-86.

(84) Croxton RS, Baron MG, Butler D, Kent T, Sears VG. Development of a GC-MS method for the simultaneous analysis of latent fingerprint components. *Journal of Forensic Sciences* 2006; 51 (6)**:** 1329-1333.

(85) Zhang Z-M, Cai J-J, Ruan G-H, Li G-K. The study of fingerprint characteristics of the emanations from human arm skin using the original sampling system by SPME-GC/MS. *Journal of Chromatography B* 2005; 822 (1-2)**:** 244-252.

(86) Almog J, Azoury M, Elmaliah Y, Berenstein L, Zaban A. Fingerprints' third dimension: The depth and shape of fingerprints penetration into paper - cross section examination by fluorescence microscopy. *Journal of Forensic Sciences* 2004; 49 (5)**:** 981-985.

(87) Wallace-Kunkel C, Lennard C, Stoilovic M, Roux C. Optimisation and evaluation of 1,2-indanedione for use as a fingermark reagent and its application to real samples. *Forensic Science International* 2007; 168 (1)**:** 14-26.

(88) Levinton-Shamuilov G, Cohen Y, Azoury M, Chaikovsky A, Almog J. Genipin, a novel fingerprint reagent with colorimetric and fluorogenic activity, part ii: Optimization, scope and limitations. *Journal of Forensic Sciences* 2005; 50 (6)**:** 1367-1371.

(89) Wallace-Kunkel C, Roux C, Lennard C, Stoilovic M. The detection and enhancement of latent fingermarks on porous surfaces - a survey. *Journal of Forensic Identification* 2004; 54 (6)**:** 687-705.

(90) Hugh L. Comparison analysis of the efficiency of different treatments for latent fingerprint development. *Fingerprint Whorld* 2005; 31 (120)**:** 82-86.

(91) Flynn K, Maynard P, Du Pasquier E, Lennard C, Stoilovic M, Roux C. Evaluation of iodine-benzoflavone and ruthenium tetroxide spray reagents for the detection of latent fingermarks at the crime scene. *Journal of Forensic Sciences* 2004; 49 (4)**:** 707-715.

(92) Almog J, Levinton-Shamuilov G, Cohen Y, Azoury M. Fingerprint reagents with dual action: Color and fluorescence. *Journal of Forensic Sciences* 2007; 52 (2)**:** 330-334.

(93) Hansen DB, Joullié MM. The development of novel ninhydrin analogues. *Chemical Society Reviews* 2005; 34**:** 408-417.

(94) Petraco NDK, Proni G, Jackiw JJ, Sapse A-M. Amino acid alanine reactivity with the fingerprint reagent ninhydrin. A detailed ab initio computational study. *Journal of Forensic Sciences* 2006; 51 (6)**:** 1267-1275.

(95) Voller B, Moraru E, Auff E, Benesh M, Poewe W, Wissel J*, et al.* Ninhydrin sweat test: A simple method for detecting antibodies neutralizing botulinum toxin type a. *Movement Disorders* 2004; 19 (8)**:** 943-947.

(96) Sun S-W, Lin Y-C, Weng Y-M, Chen M-J. Efficiency improvements on ninhydrin method for amino acid quantification. *Journal of Food Composition and Analysis* 2006; 19 (2-3)**:** 112-117.

(97) Alaoui IM, Menzel ER, Farag M, Cheng KH, Murdock RH. Mass spectra and time-resolved fluorescence spectroscopy of the reaction product of glycine with 1,2-indanedione in methanol. *Forensic Science International* 2005; 152 (2-3)**:** 215-219.

(98) Yu P-H, Wallace MM. Effect of 1,2-indanedione on PCR-STR typing of fingerprints deposited on thermal and carbonless paper. *Forensic Science International* 2007; 168 (2-3)**:** 112-118.

(99) Stoilovic M, Lennard C, Wallace-Kunkel C, Roux C. Evaluation of a 1,2-indanedione formulation containing zinc chloride for improved fingermark detection on paper. *Journal of Forensic Identification* 2007; 57 (1)**:** 4-18.

(100) Edwards HGM, Day JS. Fourier transform Raman spectroscopic studies of the curing of cyanoacrylate glue. *Journal of Raman Spectroscopy* 2004; 35**:** 555-560.

(101) Kent T. Letter to the editor - a comparison of cyanoacrylate fuming in vacuum cabinet to a humidity fuming chamber. *Journal of Forensic Identification* 2005; 55 (6)**:** 681-686.

(102) Mankidy PJ, Rajagopalan R, Foley HC. Facile catalytic growth of cyanoacrylate nanofibers. *Chemical Communications* 2006**:** 1139-1141.

(103) Edwards HGM, Day JS. Anomalies in polycyanoacrylate formation studied by Raman spectroscopy: Implications for the forensic enhancement of latent fingerprints for spectral analysis. *Vibrational Spectroscopy* 2006; 41 (2)**:** 155-159.

(104) Czekanski P, Fasola M, Allison J. A mechanistic model for the superglue fuming of latent fingerprints. *Journal of Forensic Sciences* 2006; 51 (6)**:** 1323-1328.

(105) Tomlinson SK, Ghita OR, Hooper RM, Evans KE. The use of near-infrared spectroscopy for the cure monitoring of an ethyl cyanoacrylate adhesive. *Vibrational Spectroscopy* 2006; 40 (1)**:** 133-141.

(106) HOSDB. *PSDB Fingerprint development and imaging newsletter* 2004; April (71/04).

(107) Bessman CW, Nelson E, Lipert RJ, Coldiron S, Herrman TR. A comparison of cyanoacrylate fuming in a vacuum cabinet to a humidity fuming chamber. *Journal of Forensic Identification* 2005; 55 (1)**:** 10-27.

(108) Day JS, Edwards HGM, Dobrowski SA, Voice AM. The detection of drugs of abuse in fingerprints using Raman spectroscopy ii: Cyanoacrylate-fumed fingerprints. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 2004; 60 (8-9)**:** 1725-1730.

(109) Bandey HL. The powders process, study 1: Evaluation of fingerprint brushes for use with aluminium powder. *PSDB Fingerprint Development and Imaging Newsletter* 2004; August (54/04)**:** 1-12.

(110) Bandey H, Gibson AP. The powders process, study 2: Evaluation of fingerprint powders on smooth surfaces. *HOSDB Fingerprint Development and Imaging Newsletter* 2006; February (08/06)**:** 1-13.

(111) Bandey H, Hardy T. The powders process, study 3: Evaluation of fingerprint powders on textured surfaces and u-PVC. *HOSDB Fingerprint and Footwear Forensics Newsletter* 2006; December (67/06)**:** 1-11.

(112) Bandey HL. Fingerprint powders guidelines. *HOSDB Fingerprint and Footwear Forensics Newsletter* 2007; March (09/07)**:** 1-4.

(113) Sodhi GS, Kaur J. A fingerprint powder formulation involving cyano blue dye. *Fingerprint Whorld* 2004; 30 (118)**:** 163-163.

(114) Sodhi GS, Kaur J. Proflavin-based fingerprint dusting composition. *Fingerprint Whorld* 2005; 31 (122)**:** 239-239.

(115) Kaur K. Novel fluorescent fingerprint dusting compositions. *Fingerprint Whorld* 2006; 33 (126)**:** 20-24.

(116) Saroa JS, Sodhi GS, Garg RK. Evaluation of fingerprint powders. *Journal of Forensic Identification* 2006; 56 (2)**:** 186-197.

(117) Saroa JS, Sodhi GS, Garg RK. Correction - evaluation of fingerprint powders. *Journal of Forensic Identification* 2006; 56 (5)**:** 681-684.

(118) Azoury M, Rozen E, Uziel Y, Peleg-Shironi Y. Old latent prints developed with powder: A rare phenomenon? *Journal of Forensic Identification* 2004; 54 (5)**:** 534-541.

(119) Seah LK, Dinish US, Phang WF, Chao ZX, Murukeshan VM. Fluorescence optimisation and lifetime studies of fingerprints treated with magnetic powders. *Forensic Science International* 2005; 152 (2-3)**:** 249-257.

(120) Cucè P, Polimeni G, Lazzaro AP, De Fulvio G. Small particle reagents technique can help to point out wet latent fingerprints. *Forensic Science International* 2004; 146 (Supplement 1)**:** S7-S8.

(121) Polimeni G, Feudale Foti B, Saravo L, De Fulvio G. A novel approach to identify the presence of fingerprints on wet surfaces. *Forensic Science International* 2004; 146 (Supplement 1)**:** S45-S46.

(122) Jasuja OP, Singh GD, Sodhi GS. Small particle reagent: A saponin-based modification. *Journal of Forensic Identification* 2007; 57 (2)**:** 244-251.

(123) Choi MJ, McDonagh AM, Maynard P, Wuhrer R, Lennard C, Roux C. Preparation and evaluation of metal nanopowders for the detection of fingermarks on nonporous surfaces. *Journal of Forensic Identification* 2006; 56 (5)**:** 756-768.

(124) Sodhi GS, Kaur J. Nanoparticle size fingerprint dusting composition based on fluorescent eosin Y dye. *Fingerprint Whorld* 2006; 32 (125)**:** 146-147.

(125) Choi MJ, Smoother T, Martin AA, McDonagh AM, Maynard PJ, Lennard C*, et al.* Fluorescent TiO2 powders prepared using a new perylene diimide dye: Applications in latent fingermark detection. *Forensic Science International* 2007; In Press, Corrected Proof.

(126) Leggett R, Lee-Smith EE, Jickells SM, Russel DA. "Intelligent" Fingerprinting: Simultaneous identification of drug metabolites and individuals by using antibody-functionalized nanoparticles. *Angewandte Chemie* 2007; 119**:** 4178-4181.

(127) Leggett R, Lee-Smith EE, Jickells SM, Russel DA. "Intelligent" Fingerprinting: Simultaneous identification of drug metabolites and individuals by using antibody-functionalized nanoparticles. *Angewandte Chemie International Edition* 2007; 46**:** 4100-4103.

(128) Sametband M, Shweky I, Banin U, Mandler D, Almog J. Application of nanoparticles for the enhancement of latent fingerprints. *Chemical Communications* 2007**:** 1142-1144.

(129) Theaker BJ, Hudson KE, Rowell FJ. Doped hydrophobic silica nano- and micro-particles as novel agents for developing latent fingerprints. *Forensic Science International* 2007; In Press, Corrected Proof.

(130) Choi MJ, McBean KE, Wuhrer R, McDonagh AM, Maynard PJ, Lennard C*, et al.* Investigation into the binding of gold nanoparticles to fingermarks using scanning electron microscopy. *Journal of Forensic Identification* 2006; 56 (1)**:** 24-32.

(131) Becue A, Champod C, Margot P. Use of gold nanoparticles as molecular intermediates for the detection of fingermarks. *Forensic Science International* 2007; 168**:** 169-176.

(132) Stauffer E, Becue A, Singh KV, Thampi KR, Champod C, Margot P. Single-metal deposition (SMD) as a latent fingermark enhancement technique: An alternative to multimetal deposition (MMD). *Forensic Science International* 2007; 168 (1)**:** e5-e9.

(133) Yapping L, Yue W. A new silver physical developer. *Journal of Forensic Identification* 2004; 54 (4)**:** 422-427.

(134) Cantu AA. Letter to the editor - a new silver physical developer. *Journal of Forensic Identification* 2005; 55 (3)**:** 289-290.

(135) HOSDB. *HOSDB Fingerprint Development and Imaging Newsletter* 2005; April (20/05).

(136) Beaudoin A. New technique for revealing latent fingerprints on wet, porous surfaces: Oil Red O. *Journal of Forensic Identification* 2004; 54 (4)**:** 413-420.

(137) Rawji A, Beaudoin A. Oil Red O versus physical developer on wet papers: A comparative study. *Journal of Forensic Identification* 2006; 56 (1)**:** 33-54.

(138) Guigui K, Beaudoin A. The use of Oil Red O in sequence with other methods of fingerprint development. *Journal of Forensic Identification* 2007; 57 (4)**:** 550-581.

(139) Li C, Li B, Yu S, Gao J, Yao P. Study on the direct developing of a latent fingerprint using a new fluorescent developer. *Journal of Forensic Identification* 2004; 54 (6)**:** 653-659.

(140) Menzel ER, Schwierking JR, Menzel LW. Functionalized europium oxide nanoparticles for fingerprint detection: A preliminary study. *Journal of Forensic Identification* 2005; 55 (2)**:** 189-195.

(141) HOSDB. *HOSDB Fingerprint Development and Imaging Newsletter* 2005; October (47/05).

(142) Dai X, Stoilovic M, Lennard C, Speers N. Vacuum metal deposition: Visualisation of gold agglomerates using TEM imaging. *Forensic Science International* 2007; 168 (2-3)**:** 219-222.

(143) Philipson D, Bleay S. Alternative metal processes for vacuum metal deposition. *Journal of Forensic Identification* 2007; 57 (2)**:** 252-273.

(144) Sturelle V, Cominotti C, Henrot D, Desbrosse X. The use of camphor in the development of latent prints on unfired cartridge casings. *Journal of Forensic Identification* 2006; 56 (5)**:** 694-705.

(145) Grzegorzewska E, Filbrandt B. Enhancement of latent fingermarks with RTX method. *Problemy Kryminalistyki* 2004 (246)**:** 19-26.

(146) Day JS, Edwards HGM, Dobrowski SA, Voice AM. The detection of drugs of abuse in fingerprints using Raman spectroscopy i: Latent fingerprints. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 2004; 60**:** 563-568.

(147) Rosati BB. Does superglue hinder traditional firearms identification? *AFTE Journal* 2005; 37 (1)**:** 3-6.

(148) Schnetz B, Margot P. Technical note: Latent fingermarks, colloidal gold and multimetal deposition (MMD). Optimisation of the method. *Forensic Science International* 2001; 118**:** 21-28.

(149) Wilson JD, Cantu AA, Antonopoulos G, Surrency MJ. Examination of the steps leading up to the physical developer process for developing fingerprints. *Journal of Forensic Sciences* 2007; 52 (2)**:** 320-329.

(150) Gunaratne A, Knaggs C, Stansbury D. Vacuum metal deposition: Comparing conventional gold/zinc VMD to aluminium VMD. *Identification Canada* 2007; 30 (2)**:** 40-62.

(151) Marshall AM, Gwynne B. The application of "Crimelite" To examination of computer components "In situ". *Science & Justice* 2005; 45 (3)**:** 151-155.

(152) Vandenberg N, van Oorschot RAH. The use of Polilight in the detection of seminal fluid, saliva, and bloodstains and comparison with conventional chemical-based screening tests. *Journal of Forensic Sciences* 2006; 51 (2)**:** 361-370.

(153) Hughes VK, Ellis PS, Langlois NEI. Alternative light source (polilight) illumination with digital image analysis does not assist in determining the age of bruises. *Forensic Science International* 2006; 158 (2-3)**:** 104-107.

(154) Dyer AG, Muir LL, Muntz WRA. A calibrated gray scale for forensic ultraviolet photography. *Journal of Forensic Sciences* 2004; 49 (5)**:** 1056-1058.

(155) Menzel ER, Bouldin KK, Murdock RH. Trace explosives detection by photoluminescence. *TheScientificWorldJOURNAL* 2004; 4**:** 55-66.

(156) HOSDB. Additional fingerprint development techniques for adhesive tapes. *HOSDB Fingerprint Development and Imaging Newsletter* 2006; March (23/06).

(157) Saitoh N, Akiba N. Ultraviolet fluorescence spectra of fingerprints. *TheScientificWorldJOURNAL* 2005; 5**:** 355-366.

(158) Saitoh N, Akiba N. Ultraviolet fluorescence imaging of fingerprints. *TheScientificWorldJOURNAL* 2006; 6**:** 691-699.

(159) Walsh J. End of the spectrum: Revealing more than meets the eye. *Spectroscopy* 2005; July 1.

(160) Jones WD. X-ray vision picks up clues to crimes. *IEEE Spectrum online* 2005; June**:** http://www.spectrum.ieee.org/jun05/2672.

(161) Worley CG, Wiltshire SS, Miller TC, Havrilla GJ, Majidi V. Detection of visible and latent fingerprints using micro-x-ray fluorescence elemental imaging. *Journal of Forensic Sciences* 2006; 51 (1)**:** 57-63.

(162) Flynn K, O'Leary R, Lennard C, Roux C, Reedy BJ. Forensic applications of infrared chemical imaging: Multi-layered paint chips. *Journal of Forensic Sciences* 2005; 50 (4)**:** 832-841.

(163) Payne G, Reedy B, Lennard C, Comber B, Exline D, Roux C. A further study to investigate the detection and enhancement of latent fingerprints using visible absorption and luminescence chemical imaging. *Forensic Science International* 2005; 150 (1)**:** 33-51.

(164) Miskelly GM, Wagner JH. Using spectral information in forensic imaging. *Forensic Science International* 2005; 155 (2-3)**:** 112-118.

(165) Tahtouh M, Kalman JR, Roux C, Lennard C, Reedy BJ. The detection and enhancement of latent fingermarks using infrared chemical imaging. *Journal of Forensic Sciences* 2005; 50 (1)**:** 64-72.

(166) Chan KLA, Kazarian SG. Detection of trace materials with Fourier transform infrared spectroscopy using a multi-channel detector. *Analyst* 2006; 131**:** 126-131.

(167) Crane NJ, Bartick EG, Perlman RS, Huffman S. Infrared spectroscopic imaging for noninvasive detection of latent fingerprints. *Journal of Forensic Sciences* 2007; 52 (1)**:** 48-53.

(168) Ricci C, Phiriyavityopas P, Curum N, Chan KLA, Jickells S, Kazarian SG. Chemical imaging of latent fingerprint residues. *Applied Spectroscopy.* 2007; 61 (5)**:** 514-522.

(169) Williams G, McMurray N. Latent fingermark visualisation using a scanning Kelvin probe. *Forensic Science International* 2007; 167 (2-3)**:** 102-109.

(170) Seah LK, Dinish US, Ong SK, Chao ZX, Murukeshan VM. Time-resolved imaging of latent fingerprints with nanosecond resolution. *Optics & Laser Technology* 2004; 36 (5)**:** 371-376.

(171) Dinish US, Chao ZX, Seah LK, Singh A, Murukeshan VM. Formulation and implementation of a phase-resolved fluorescence technique for latent-fingerprint imaging: Theoretical and experimental analysis. *Applied Optics* 2005; 44**:** 297-304.

(172) Seah LK, Wang P, Murukeshan VM, Chao ZX. Application of fluorescence lifetime imaging (flim) in latent finger mark detection. *Forensic Science International* 2006; 160 (2-3)**:** 109-114.

(173) Zhang M, Girault HH. Fingerprint imaging by scanning electrochemical microscopy. *Electrochemistry Communications* 2007; 9**:** 1778-1782.

(174) Bleay SM, Kent T. The use of infra-red filters to remove background patterns in fingerprint imaging. *Fingerprint Whorld* 2005; 31 (122)**:** 225-238.

(175) Thali MJ, Braun M, Buck U, Aghayev E, Jackowski C, Vock P*, et al.* Virtopsy - scientific documentation reconstruction and animation in forensic: Individual and real 3D data based geometric approach including optical body/object surface and radiological CT/MRI scanning. *Journal of Forensic Sciences* 2005; 50 (2)**:** 428-442.

(176) Gulick G. Adding a totally new dimension to the process of print analysis and comparison. *Fingerprint Whorld* 2004; 30 (117)**:** 109-113.

(177) Chaikovsky A, Argaman U, Balman A, Sin-David L, Barzovski A, Yaalon U. Multiple exposure method in digital photography of fingerprints. *Journal of Forensic Identification* 2005; 55 (5)**:** 574-584.

(178) Day C, Wertheim K. High dynamic range fingerprint images in Photoshop CS2. *The Weekly Detail* 2005; June 6**:** http://www.clpex.com/Articles/TheDetail/100-199/TheDetail199.htm.

(179) Lackey B. Latent fingerprint imaging: How to reproduce an image of a latent print to a specific size. *Journal of Forensic Identification* 2005; 55 (3)**:** 306-311.

(180) Blotta E, Moler E. Fingerprint image enhancement by differential hysteresis processing. *Forensic Science International* 2004; 141 (2-3)**:** 109-113.

(181) Sears VG, Butcher CPG, Fitzgerald LA. Enhancement of fingerprints in blood - part 3: Reactive techniques, acid yellow 7, and process sequences. *Journal of Forensic Identification* 2005; 55 (6)**:** 741-763.

(182) Dilbeck L. Use of Bluestar forensic in lieu of luminol at crime scenes. *Journal of Forensic Identification* 2006; 56 (5)**:** 706-720.

(183) Young T. A photographic comparison of luminol, fluorescein, and Bluestar. *Journal of Forensic Identification* 2006; 56 (6)**:** 906-912.

(184) Marchant B, Tague C. Developing fingerprints in blood: A comparison of several chemical techniques. *Journal of Forensic Identification* 2007; 57 (1)**:** 76-93.

(185) Jakovich CJ. STR analysis following latent blood detection by luminol, fluorescein, and Bluestar. *Journal of Forensic Identification* 2007; 57 (2)**:** 193-198.

(186) Tug A, Alakoç YD, Hanci IH. An end to a rumour. *Forensic Science International* 2005; 153**:** 156-160.

(187) Webb JL, Creamer JI, Quickenden TI. A comparison of the presumptive luminol test for blood with four non-chemiluminescent forensic techniques. *Luminescence* 2006; 21**:** 214-220.

(188) Bily C, Maldonado H. The application of luminol to bloodstains concealed by multiple layers of paint. *Journal of Forensic Identification* 2006; 56 (6)**:** 896-912.

(189) Barni F, Lewis SW, Berti A, Miskelly GM, Lago G. Forensic application of the luminol reaction as a presumptive test for latent blood detection. *Talanta* 2007; 72 (3)**:** 896-913.

(190) Yapping L, Yue W. Bloody latent fingerprint detection using LeuR6G. *Journal of Forensic Identification* 2004; 54 (5)**:** 542-546.

(191) Wang Y, Weiping Z, Janping M. Eosin Y detection of latent blood prints. *Journal of Forensic Identification* 2007; 57 (1)**:** 54-58.

(192) Ginestra E, Trapani C, Martino DD, Saravo L. DNA extraction from blood determination membrane card test. *Forensic Science International* 2004; 146 (Supplement 1)**:** S145-S146.

(193) Anderson S, Howard B, Hobbs GR, Bishop CP. A method for determining the age of a bloodstain. *Forensic Science International* 2005; 148 (1)**:** 37-45.

(194) Fujita Y, Tsuchiya K, Abe S, Takiguchi Y, Kubo S-i, Sakurai H. Estimation of the age of human bloodstains by electron paramagnetic resonance spectroscopy: Long-term controlled experiment on the effects of environmental factors. *Forensic Science International* 2005; 152 (1)**:** 39-43.

(195) Strasser S, Zink A, Kada G, Hinterdorfer P, Peschel O, Heckl WM*, et al.* Age determination of blood spots in forensic medicine by force spectroscopy. *Forensic Science International* 2007; 170 (1)**:** 8-14.

(196) Martin LA, Cahill CF. Recovery of DNA from latent blood after identification by fluorescein. *Journal of Forensic Identification* 2004; 54 (6)**:** 660-667.

(197) Seraglia R, Teatino A, Traldi P. Maldi mass spectrometry in the solution of some forensic problems. *Forensic Science International* 2004; 146 (Supplement 1)**:** S83-S85.

(198) Wakefield M, Armitage S. The development of latent fingerprints on thermal paper using a novel, solvent-free method. *Journal of Forensic Identification* 2005; 55 (2)**:** 202-213.

(199) Ma R, Wei Q. Chemical fuming: A practical method for fingerprint development on thermal paper. *Journal of Forensic Identification* 2006; 56 (3)**:** 364-373.

(200) Schwarz L, Klenke I. Enhancement of ninhydrin- or DFO-treated latent fingerprints on thermal paper. *Journal of Forensic Sciences* 2007; 52 (3)**:** 649-655.

(201) Siegel SD. The use of cellophane tape to overcome the background discoloration on thermal paper. *Journal of Forensic Identification* 2007; 57 (2)**:** 240-243.

(202) HOSDB. *HOSDB Fingerprint and Footwear Forensics Newsletter* 2006; October (58/06).

(203) Brzozowski J, Bialek I, Subik P. Visualisation of fingerprints on sticky side of adhesive tapes. *Problems of Forensic Sciences* 2005; LXIV**:** 333-342.

(204) Schiemer C, Lennard C, Maynard P, Roux C. Evaluation of techniques for the detection and enhancement of latent fingermarks on black electrical tape. *Journal of Forensic Identification* 2005; 55 (2)**:** 214-238.

(205) Williams NH, Elliott KT. Development of latent prints using titanium dioxide (TiO2) in small particle reagent, white (SPR-w) on adhesives. *Journal of Forensic Identification* 2005; 55 (3)**:** 292-305.

(206) HOSDB. *HOSDB Fingerprint Development and Imaging Newsletter* 2006; May (34/06).

(207) Deans J. Recovery of fingerprints from fire scenes and associated evidence. *Science & Justice* 2006; 46 (3)**:** 153-168.

(208) Bleay SM, Bradshaw G, Moore JE. Special edition - arson scenes. *HOSDB Fingerprint Development and Imaging Newsletter* 2006; April (26/06)**:** 1-30.

(209) Stow KM, McGurry J. The recovery of finger marks from soot-covered glass fire debris. *Science & Justice* 2006; 46 (1)**:** 3-14.

(210) Wyllie J. The recovery of fingerprints from arson scenes. *Fingerprint Whorld* 2006; 32 (124)**:** 86-92.

(211) Raymond JJ, Walsh SJ, Van Oorschot RA, Gunn PR, Roux C. Trace DNA: An underutilized resource or pandora's box? A review of the use of trace DNA analysis in the investigation of volume crime. *Journal of Forensic Identification* 2004; 54 (6)**:** 668-686.

(212) Schulz MM, Wehner HD, Reichert W, Graw M. Ninhydrin-dyed latent fingerprints as a DNA source in a murder case. *Journal of Clinical Forensic Medicine* 2004; 11 (4)**:** 202-204.

(213) Leemans P, Vandeput A, Vanderheyden N, Cassiman J-J, Decorte R. Evaluation of methodology for the isolation and analysis of LCN-DNA before and after dactyloscopic enhancement of fingerprints. *International Congress Series* 2006; 1288**:** 583-585.

(214) Prinz M, Schiffner L, Sebestyen JA, Bajda E, Tamariz J, Shaler RC*, et al.* Maximization of STR DNA typing success for touched objects. *International Congress Series* 2006; 1288**:** 651-653.

(215) Petricevic SF, Bright J-A, Cockerton SL. DNA profiling of trace DNA recovered from bedding. *Forensic Science International* 2006; 159 (1)**:** 21-26.

(216) Van Oorschot RAH, Treadwell S, Beaurepaire J, Holding NL, Mitchell RJ. Beware of the possibility of fingerprinting techniques transferring DNA. *Journal of Forensic Sciences* 2005; 50 (6)**:** 1417-1422.

(217) Proff C, Schmitt C, Schneider PM, Foerster G, Rothschild MA. Experiments on the DNA contamination risk via latent fingerprint brushes. *International Congress Series* 2006; 1288**:** 601-603.

(218) Kennedy RB, Yamashita AB. Barefoot morphology comparison: A summary. *Journal of Forensic Identification* 2007; 57 (3)**:** 383-413.

(219) Kennedy RB, Chen S, Pressman IS, Yamashita AB, Pressman AE. A large-scale statistical analysis of barefoot impressions. *Journal of Forensic Sciences* 2005; 50 (5)**:** 1071-1080.

(220) Krishan K. Individualizing characteristics of footprints in Gujjars of North India - forensic aspects. *Forensic Science International* 2007; 169 (2-3)**:** 137-144.

(221) Krishan K. Estimation of stature from dimensions of hands and feet in a North Indian population. *Journal of Forensic and Legal Medicine* 2007; 14**:** 327-332.

(222) Krishan K. Estimation of stature from footprint and foot outline dimensions in Gujjars of North India. *Forensic Science International* 2007; In Press, Corrected Proof.

(223) Taranto J, Taranto MJ, Bryant A, Singer KP. Angle of gait: A comparative reliability study using footprints and the emed-sf. *The Foot* 2005; 15 (1)**:** 7-13.

(224) Curran SA, Upton D, Learmonth ID. Dynamic and static footprints: Comparative calculations for angle and base of gait. *The Foot* 2005; 15 (1)**:** 40-46.

(225) Urry SR, Wearing SC. Arch indexes from ink footprints and pressure platforms are different. *The Foot* 2005; 15 (2)**:** 68-73.

(226) Nikolaidou ME, Boudolos KD. A footprint-based approach for the rational classification of foot types in young schoolchildren. *The Foot* 2006; 16 (2)**:** 82-90.

(227) Fresco A. Earprint evidence a 'grotesque injustice'. *Fingerprint Whorld* 2004; 30 (116)**:** 57.

(228) Rutty GN, Abbas A, Crossling D. Could earprint identification be computerised? An illustrated proof of concept paper. *International Journal of Legal Medicine* 2005; 119**:** 335-343.

(229) Meijerman L, Sholl S, De Conti F, Giacon M, van der Lugt C, Drusini A*, et al.* Exploratory study on classification and individualisation of earprints. *Forensic Science International* 2004; 140**:** 91-99.

(230) Meijerman L. *Inter- and intra-individual variations in earprints*. PhD, Department of Anatomy and Embryology, University of Leiden, Leiden:2006.

(231) Alberink IB, Ruifrok ACC, Kieckhoefer H. Interoperator test for anatomical annotation of earprints. *Journal of Forensic Sciences* 2006; 51 (6)**:** 1246–1254.

(232) Alberink I, Ruifrok A. Performance of the fearid earprint identification system. *Forensic Science International* 2007; 166 (2-3)**:** 145-154.

(233) Abbas A, Rutty GN. Ear piercing affects earprints: The role of ear piercing in human identification. *Journal of Forensic Sciences* 2005; 50 (2)**:** 386-392.

(234) Choras M. Ear biometrics based on geometrical method of feature extraction. *AMDO* 2004; LNCS 3179**:** 51-61.

(235) Pun KH, Moon YS. Recent advances in ear biometrics. *Proceeding of the Sixth IEEE International Conference on Automatic Face and Gesture Recognition (FRG'04)* 2004.

(236) Choras M. Ear biometrics based on geometrical feature extraction. *Electronic Letters on Computer Vision and Image Analysis* 2005; 5 (3)**:** 84-95.

(237) Hurley DJ, Nixon MS, Carter JN. Force field feature extraction for ear biometrics. *Computer Vision and Image Understanding* 2005; 98**:** 491-512.

(238) Lammi H-K (2005) Ear biometrics. Lappeenranta, Finland, Lappeenranta University of Technology.

(239) Castelló A, Alvarez-Seguí M, Verdú F. Luminous lip-prints as criminal evidence. *Forensic Science International* 2005; 155 (2-3)**:** 185-187.

(240) Navarro E, Castelló A, López JL, Verdú F. Criminalistic: Effectiveness of lysochromes on the developing of invisible lipstick-contaminated lipmarks on human skin: A preliminary study. *Forensic Science International* 2006; 158 (1): 9-13.

(241) Navarro E, Castelló A, López-Alfaro JA, Verdú F. More about the developing of invisible lipstick-contaminated lipmarks on human skin: The usefulness of fluorescent dyes. *Journal of Clinical Forensic Medicine* 2007; In Press, Corrected Proof.

(242) Utsuno H, Kanoh T, Tadokoro O, Inoue K. Preliminary study of post mortem identification using lip prints. *Forensic Science International* 2005; 149 (2-3): 129-132.

(243) Szurgocinska A. Variation of lip red in persons playing wind instruments and its relevance to forensic cases. *Problemy Kryminalistyki* 2004 (246): 38-48.

(244) Castelló A, Alvarez M, Verdú F. Just lip prints? No: There could be something else. *The FASEB Journal* 2004; 18: 615-616.

(245) Bowers CM. Problem-based analysis of bitemark misidentifications: The role of DNA. *Forensic Science International* 2006; 159 (Supplement 1): S104-S109.

(246) Pretty IA. The barriers to achieving an evidence base for bitemark analysis. *Forensic Science International* 2006; 159 (Supplement 1): S110-S120.

(247) Pretty IA. Development and validation of a human bitemark severity and significance scale. *Journal of Forensic Sciences* 2007; 52 (3): 687-691.

(248) Bowers CM. Identification from bitemarks, §38-2. In Faigman DL, Kaye DH, Saks MJ, Sanders J, Cheng EK (Eds.). *Modern scientific evidence: The law and science of expert testimony.* (2007) Eagan, MN, Thompson/West Publishing Co.: 625-698.

(249) Biwasaka H, Saigusa K, Aoki Y. The applicability of holography in forensic identification: A fusion of the traditional optical technique and digital technique. *Journal of Forensic Sciences* 2005; 50 (2): 393-399.

(250) McNamee AH, Sweet D, Pretty I. A comparative reliability analysis of computer-generated bitemark overlays. *Journal of Forensic Sciences* 2005; 50 (2): 400-405.

(251) Martin-de las Heras S, Valenzuela A, Ogayar C, Valverde AJ, Torres JC. Computer-based production of comparison overlays from 3D-scanned dental casts for bite mark analysis. *Journal of Forensic Sciences* 2005; 50 (1): 127-133.

(252) Al-Talabani N, Al-Moussawy ND, Baker FA, Mohammed HA. Digital analysis of experimental human bitemarks: Application of two new methods. *Journal of Forensic Sciences* 2006; 51 (6): 1372-1375.

(253) Martin-de las Heras S, Valenzuela A, Javier Valverde A, Torres JC, Luna-del-Castillo JD. Effectiveness of comparison overlays generated with dentalprint software in bite mark analysis. *Journal of Forensic Sciences* 2007; 52 (1): 151-156.

(254) Bernitz H, van Heerden WFP, Solheim T, Owen JH. A technique to capture, analyze, and quantify anterior teeth rotations for application in court cases involving tooth marks. *Journal of Forensic Sciences* 2006; 51 (3): 624-629.

(255) Dixon B. Identifying bite marks. *The Lancet Infectious Diseases* 2006; 6 (3): 127-127.

(256) Hunt AC. Ring-resolution of bruises - a little recognised phenomenon. *Journal of Forensic and Legal Medicine* 2007; 14: 85-86.

(257) Tomboc R. Marks on skin were caused by ants. *Journal of Forensic Identification* 2006; 56 (5): 726-729.

(258) Murmann DC, Brumit PC, Schrader BA, Senn DR. A comparison of animal jaws and bite mark patterns. *Journal of Forensic Sciences* 2006; 51 (4): 846-860.

(259) Freeman AJ, Senn DR, Arendt DM. Seven hundred seventy eight bite marks: Analysis by anatomic location, victim and biter demographics, type of crime, and legal disposition. *Journal of Forensic Sciences* 2005; 50 (6): 1436-1443.

(260) Barbaro A, Cormaci P, Teatino A, La Marca A, Barbaro A. Anonymous letters? DNA and fingerprints technologies combined to solve a case. *Forensic Science International* 2004; 146 (Supplement 1): S133-S134.

(261) Polimeni G, Saravo L. A study of case dynamic by fingerprints' fragments analysis. *Forensic Science International* 2004; 146 (Supplement 1): S47-S48.

(262) Azoury M, Cohen D, Himberg K, Qvintus-Leino P, Saari T, Almog J. Fingerprint detection on counterfeit US$ banknotes: The importance of preliminary paper examination. *Journal of Forensic Sciences* 2004; 49 (5)**:** 1015-1017.

(263) Pizzamiglio M, Mameli A, Maugeri G, Garofano L. Identifying the culprit from LCN DNA obtained from saliva and sweat traces linked to two different robberies and use of a database. *International Congress Series* 2004; 1261**:** 443-445.

(264) Tomboc R. Restoring faded authentiprint fingerprint image on a check. *Journal of Forensic Identification* 2005; 55 (2)**:** 169-175.

(265) Sinclair R, Fox C. Infant-to-adult footprint identification. *Journal of Forensic Identification* 2007; 57 (4)**:** 485-492.

(266) Ramotowski RS, Regen EM. The effect of electron beam irradiation on forensic evidence - 1. Latent print recovery on porous and non-porous surfaces. *Journal of Forensic Sciences* 2005; 50 (2)**:** 298-306.

(267) Wilkinson D, Hancock J, Lecavalier P, McDiarmid C. The recovery of fingerprint evidence from crime scenes contaminated with chemical warfare agents. *Journal of Forensic Identification* 2005; 55 (3)**:** 326-361.

(268) Sampson WC, Sampson KL. Recovery of latent prints from human skin. *Journal of Forensic Identification* 2005; 55 (3)**:** 362-385.

(269) Yamashita B. Letter to the editor - recovery of latent prints from human skin. *Journal of Forensic Identification* 2005; 55 (5)**:** 566-573.

(270) Lanagan SR. Explosive effects on latent print evidence. *Journal of Forensic Identification* 2006; 56 (1)**:** 18-23.

(271) Lounsbury DA, Thompson LF. Concerns when using examination gloves at the crime scene. *Journal of Forensic Identification* 2006; 56 (2)**:** 179-185.

(272) Velders T. Visualization of latent fingerprints on used vinyl and latex gloves using gellifters. *The Weekly Detail* 2005; March 28.

(273) Pleckaitis J. Developing friction ridge detail on the interior of latex and nitrile gloves. *Journal of Forensic Identification* 2007; 57 (2)**:** 230-239.

(274) Holm C, Chafe F. Fingertips: Developing latent fingerprints on latex gloves using ninhydrin-heptane solution. *Identification Canada* 2007; 30 (2)**:** 63-68.

(275) Bailey JA, Veenker RA. An analysis of epidermal ridges on ancient Sumerian tablets. *Journal of Forensic Identification* 2005; 55 (5)**:** 594-604.

(276) Falconi M. Fingerprint may hold the answer to painting's master. *Fingerprint Whorld* 2005; 31 (120)**:** 101-102.

(277) Singh GD, Jasuja OP, Sodhi GS. Detection of latent fingerprints on fruits and vegetables: A non-destructive approach. *Fingerprint Whorld* 2006; 33 (126)**:** 28-32.

(278) Singh GD, Sodhi GS, Jasuja OP. Detection of latent fingerprints on fruits and vegetables. *Journal of Forensic Identification* 2006; 56 (3)**:** 374-381.

(279) Jasuja OP, Singh GD, Sodhi GS. Development of latent fingerprints on compact disc and its effect on subsequent data recovery. *Forensic Science International* 2006; 156 (2-3)**:** 237-241.

(280) Tomboc R, Schrader M. Obtaining fingerprint and palmprint impressions from decomposed bodies or burn victims using the mikrosil casting method. *Journal of Forensic Identification* 2005; 55 (4)**:** 471-479.

(281) Uhle AJ, Leas RL. The boiling technique: A method for obtaining quality postmortem impressions from deteriorating friction ridge skin. *Journal of Forensic Identification* 2007; 57 (3)**:** 358-382.

(282) Landes- und Bundeskriminalamt. *Leichendaktyloskopie*, Informationsblatt des Bundes und der Länder: 2007.