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Poroscopy as a Method for Personal Identificatıon: Issues and Challenges

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Abstract: Practical application of "Poroscopy" in personal identification has a dubious placein Forensic Scenario since the time it was proposed for the first time by Locard. The interest of researchers in this field could not be seen becuase of microscopic nature of the pores and use of opticle microscope. With the emergence of biometrics and image processing tools, one can analyse microscopic pores on computer screen without strain. Though studies with respect to its utility in biometrics have been accepted, the importance of poroscopy is still to be established when analysis of latent finger marks are encountered. In present work, poroscopy has been studied from its various aspects with respect to latent finger marks. We research relationship between time distance of taking ink prints and the consistency of the number of second level characteristics and pores in different zones of the first phalangs of the inked fingerprints. Then we research latent finger marks on different surfaces including unfired cartridge cases obtained and developed with various techniques to look into the results with respect to visibility of pores in corresponding positions. Pores visibility was found to be better in central zone of the fingerprints with respect of the time interval of taking prints. The visiblity of pores in developed finger marks on different surfaces differed considerably due to type of surface and method used to develop the finger mark. There was no change in pores with respect to their openness or closeness at various intervals of the day as reported by Faulds. Though poroscopy can be considered in personal identification but its use in case of identification from latent finger marks requires further studies to establish their permanency and reproducibility.

Keywords: Forensic science, II level characteristics, poroscopy, pores.

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Introduction

Locard (1912, s.1-12), who coined the term "poroscopy", was the first to report the use of sweat pores in personal identification after he noted the presence of sweat pores in unique shapes and configurations on ridges in palmer and plantar areas. These observations were further validated by Faulds (1913, s.635-636) who noted that these pores may not always show the reproducible features (opening/closing) due to physiological factors; which he referenced in the context of forgery of fingerprints. Chatterjee (1967) suggested the use of morphology of dermal ridges and coined the term "edgeoscopy". Ashbaugh (1994 and 1999) termed these features as third level details, whose quality and quantity are dependent upon a variety of factors. Subsequent research and the advent of biometric tools resulted in the development of automated fingerprint identification system (AFIS) using third level details including sweat pores, thus recognizing the significance of level III details (Wertheim and Walajtys, 2006) especially in cases of partial print examination where level two details are not sufficiently available.

Reproducibility of an identifying trait is one of the most critical factors in determining the credibility of physical evidence; little research has been done to validate the reproducibility of the use of sweat pores for personal identification. Research has established that dermal ridges present on palmer and plantar surfaces represent the fusion of cellular areas that contain openings for sweat pores. Because of their elevated boundaries, the sweat pores appear as different shaped white areas in inked fingerprints. Bindra et al. (2006) reported a detailed study of sweat pores from inked prints and described various types of shape, size, position and distance between pores. Their report illustrated that while pores could be studied from developed latent finger marks, the comparable details might sometimes be lacking. The report also indicated the disinterest of fingerprint professionals in poroscopy owing to the lack of proper devices for visualising the same. Level III details can be effectively visualized by using scanning devices like live scan with further use for personal identification. Numerous publications are available, ranging from image capturing to file storage format, which helped biometric systems in standardization of use of biometric systems for fingerprints. (Anthonioz and Champod, 2014; Choi et al., 2007; Jain et al.,2006; Murch et al.,2012), but applicability in a practical crime scene scenario where latent prints are first visualized has yet to be fully explored. The added value of third level details in case of biometrics may not be significant in a forensic situation when the quality of latent finger varies to a great extent (Champod, 2009). Gupta et al. (2007;2008; 2010) reported that the shape of the pores does not remain consistently reproducible when inked prints of the same finger were obtained on a different type of paper, or latent prints are made visible by different methods like the cyanoacrylate method. Therefore, the present study has been conducted to cover all aspects of poroscopy

related to its use for personal identification in forensic cases.
The following aspects have been studied under the current study:

a. Visibility and presence of II level detail and pores in inked prints taken during routine investigations;
b. Variation in pores at different times of the day (even in the same finger);
c. Sweat pore visibility in latent fingerprints developed on different surfaces and made visible through use of different methods and
d. Use of poroscopy where level II details of the same type are found at the same correlative position in two different fingerprints, especially in the case of partial prints.

Materials and Methods

One hundred pairs of ink fingerprints were taken on dactyloscopic cards with time distance of dactyloscopyng from five to 48 years covered a total of 100 persons. Fingerprints were picked up randomly from the ten print cards maintained in the fingerprint bureau and then picked up again from the same person after some period in years mention above. Method of comparative analysis was used between fingerprints in order to analyse the presence of the number of II level characteristics and pores in different fingerprint zones i.e. *Peripheral, Basal, Central and Delta,* (figure 1).

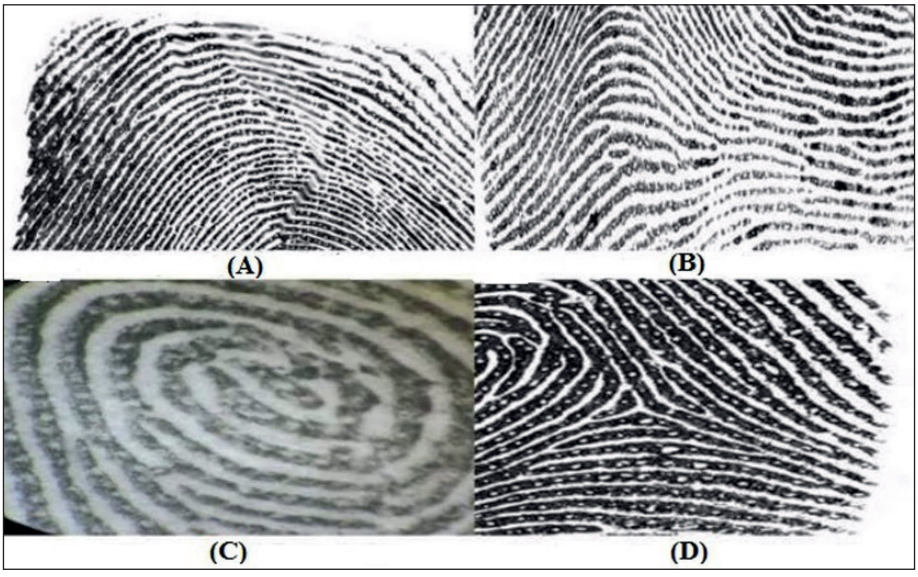

Figure 1: Fingerprint is divided into four zones: (A) Peripheral (B) Basal (C) Central (D) Delta

Namely, we research which fingerprint area stayed the most stable and kept the characteristics after certain number of years. The fingerprints were examined

under stereo microscope at 40X magnification to determine the presence of sweat pores in various regions of the rolled prints.

Rolled inked fingerprints were collected eight times from twenty volunteers at one-hour interval. These eight sets of rolled inked fingerprints obtained from each volunteer were examined under stereo microscope (40X). Pores were marked on assigned areas of ridges near the core to denote changes, i.e. open or closed. Fingerprints were also obtained via live scan for similar observations.

Latent finger marks from the same finger were obtained on bond paper, glass, polythene, plastic, metal (aluminium) and ceramic tiles, and developed by powdering (black), ninhydrin, small particle reagent (SPR) and cyanoacrylate fuming (Super Glue). Latent finger marks were collected from 10 volunteers on mentioned surfaces without any pretreatment or washing of the hand. Seven pores were marked in inked prints obtained from the same finger, and these pores were compared with the developed latent fingermarks at corresponding positions. In addition, cartridge cases were also processed for fingerprints with cyanoacrylate and post treatment with Rhodamine 6G. In case of cartridge cases treatment to observe this parameter, only 5 cases were tested.

Inked fingerprints were identified where certain level II details were almost same/alike at correlative position, but level I details were different. These fingerprints were magnified in areas where level II details were similar, and compared to determine differentiating factors between prints.

Results and Discussions

A) The visibility of sweat pores in an inked fingerprint impression can be used as an additional identification trait. The clarity of visibility, which can vary during routine inked fingerprint recordings, may be dependent upon factors such as pressure, substrate, and nature of recording medium (ink). In cases where pore visibility is minimal in inked impressions, similar visibility issues may be evident in latent fingerprints. Therefore, to determine the extent of pore visibility in routine recordings, inked fingerprints were selected at random from fingerprint bureau and examined for the presence of pores in various regions as referenced above. During comparative analysis of all 100 pairs of ink fingerprints we conclude that the central area in most of the prints exhibited the maximum number of pores while the peripheral and lateral area exhibited a minimal number of pores. It can be seen from the tables that the number of sweat pores is directly dependent on the number of second-level characteristics and the time distance between first and second taken ink prints. The number of pairs of fingerprints where pores remained stable was highest in the fingerprints whose time distance in taking prints was between 05 and 15 years and 16-25 years in the central zone of the print with a total of 56 pairs, then in the delta zone 25 pairs, in the basal zone 15 pairs and the least pronounced pores were in the peripherals zone of distal phalangs (table

1-4). How we moving to the peripheral zones of the distal phalanx of the ink print we can note reducing the number of pores that have remained stable after a certain period of time.

Table 1. Number of II level characteristics and pores in central zone of the inked fingerprints

time distance of dactyloscopyng in years	number of pairs of ink fingerprints	zone of fingerprints	number of II level characteristics	number of III level details (pores)
05-15	29	central	245	882
16-25	19	central	159	460
26-35	4	central	34	81
36-48	4	central	32	104

Table 2. Number of II level characteristics and pores in delta zone of the inked fingerprints

time distance of dactyloscopyng in years	number of pairs of ink fingerprints	zone of fingerprints	number of II level characteristics	number of III level details (pores)
05-15	16	delta	140	439
16-25	5	delta	42	117
26-35	3	delta	24	58
36-48	1	delta	8	15

Table 3. Number of II level characteristics and pores in basal zone of the inked fingerprints

time distance of dactyloscopyng in years	number of pairs of ink fingerprints	zone of fingerprints	number of II level characteristics	number of III level details (pores)
05-15	12	basal	99	274
16-25	1	basal	9	10
26-35	2	basal	16	35
36-48	0	basal	0	0

Table 4. Number of II level characteristics and pores in peripheral zone of the inked fingerprints

time distance of dactyloscopyng in years	number of pairs of ink fingerprints	zone of fingerprints	number of II level characteristics	number of III level details (pores)
05-15	2	peripheral	16	81
16-25	0	peripheral	0	0
26-35	2	peripheral	16	34
36-48	0	peripheral	0	0

This may be due to variance in pressure exerted on different areas as the fingerprint is impinged on a particular surface. Fingerprint impinging pressure varies as the donor rotates the finger, which leads to variation in results. Another reason for variation can be quantity of ink applied before recording fingerprints. Additionally, when fingerprints were recorded through the scanning system (Live Scan), some variances were reduced and more uniform results were achieved. It was interesting to note that there seems to be relationship between the number of pores in a print and the II level details in the same print. It was evident that the number of II level characteristics and pores present in each area of an inked print was increasing together. We noted that pattern type does not have role in presence of pores. (Additional studies may reveal further information pertaining to consistencies and inconsistencies in pore patterns and frequency between different fingerprint patterns.)

B) Once the use of pores in personal identification was established (Locard,1912, s.1-12), further studies reported that pores underwent physiological changes with time, i.e. they might open or close or there might be variance in their shape and size (Faulds,1913, s.635-636). It was further suggested that this phenomenon might be used to ascertain if a fingerprint is a forgery. Opening and closing of sweat pores can jeopardize the identification validity of pores as the reproducibility may have been affected; the authors were unable to find any research related to this aspect of pores. Studies related to fingerprint forgeries have been reported, including a report where 30 forgeries were detected (Geller et. al., 1999). In this report, the *Pretorius* case was mentioned where an absence of pores in forged fingerprint helped in detection of forgery instead of state of the pore as described by Faulds (1913, p. 635-636). To ascertain the status of pores at different intervals of time (whether closed or open), rolled inked fingerprints of the same finger were obtained from the same volunteer at intervals of one hour and examined under microscope to determine the status of pores. Here, ridge areas were designated as mentioned earlier. It was interesting to note that on locations under study, no additional pores were observed in fingerprints taken at different intervals of time, so the same pores were open each time. It is generally assumed that when the pore is closed it will not be visible in the ridge, but when the same is open it will be identified as an uninked area. It is important to mention here that pores may also appear closed/absent due to many other reasons including excess application of ink, too little ink, or more or less pressure applied for taking impressions. In order to eliminate the effect of ink and pressure, some fingerprint samples were obtained through live scan where no ink application is required and pressure is better controlled. It was observed that pores on those marked areas were visible in all the prints obtained at different intervals. This finding is a strong indication that absent and unclear pores in inked impressions may be caused by either excessive ink or uncontrolled pressure, which may be the reason why Faulds mentioned pores closed at some time and the same pores opened at other times (figure 2 and 3).

Figure 2: Pores in inked fingerprints taken at time interval of one hour. Sample increased 40 times

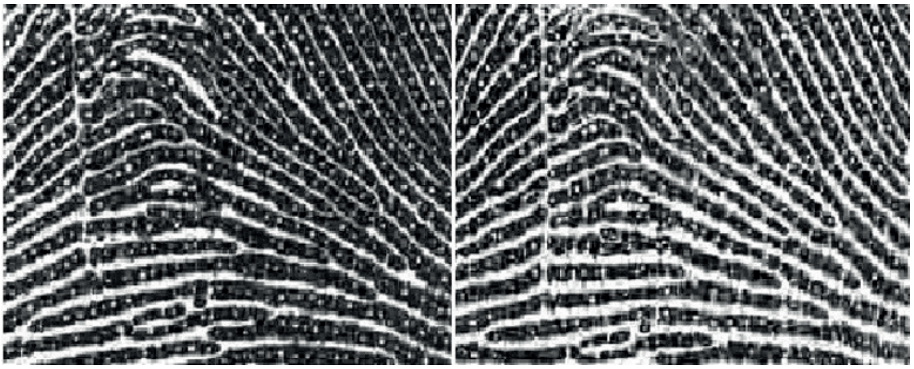

Figure 3: Pores in live scan fingerprints taken at time interval of one hour. Sample increased 40 times with 1000 dpi

This study indicated that prints obtained by Livescan were consistently of greater value than inked prints as far as presence of pores is concerned. Further, it proved that the hypothesis of pore physiology involving periodic closing and opening of pores is not true. Perhaps Faulds had noticed the closed pore at one stage while the same could have been found open at another point of time, not due to its physiology only but owning to ink and pressure as well. Previous studies also report that one must not expect to find two separate prints (inked) of the same pore to be exactly alike, as the pore may appear open in one print and closed in the other, dependent upon pressure applied (Ashbaugh, 1994; 1999). Oklevski (2010;2011) reported the stability of pores and ridge edge features over a long period of time (up to 48 years in the sample studied). The need for studies on multiple sets of inked impressions taken at different times has been emphasized

so that variations in pores can be defined (Champod, 2009). The present work comparing pores in inked prints and prints from live scan clearly indicates that the open and close state of the pore is affected by ink and pressure and not the physiology of the pore only.

C) After establishing permanency and consistency in pores, the next stage was to establish the reproducibility of pores in developed latent prints. Therefore, latent marks were obtained on different surfaces and treated with different methods to make them visible. Latent fingerprints were obtained on selected surfaces from ten volunteers. A total of seven pores in a particular region of inked fingerprints were located and marked to compare with pores from latent prints developed in a corresponding position. It was observed that the visibility and number of pores in cases of latent finger marks was different depending upon the type of surface they were lifted from and the method used for developing the latent print (Table 5).

Table 5: Pores in latent fingerprints

S.No.	Development Methods	Surfaces	Number of visible pores
1.	Powdering	Ceramic tile	7
		Glass	5
		Polythene	5
2.	Ninhydrin	Metal	4
		Paper	0
		Plastic	4
3.	Small Particle Reagent	Polythene	1
		Metal	1
		Ceramic tile	5
		Glass	1
4.	Cyanoacrylate	Glass	3
		Ceramic tile	4
		Metal	5
		Polythene	4
5.	Inked Fingerprint	Paper	7

One of the essential elements of an identification trait is the reproducibility of the same. If pores are to be used for personal identification, then they must be reproducible in latent finger marks exactly in the corresponding position as in inked prints. In the present study, the effect of various substrates and development methods on relative pore location (reproducibility) were considered. It is evident that sweat pores were visible to differing degrees in developed prints irrespective of development methods (figure 4 and figure 5).

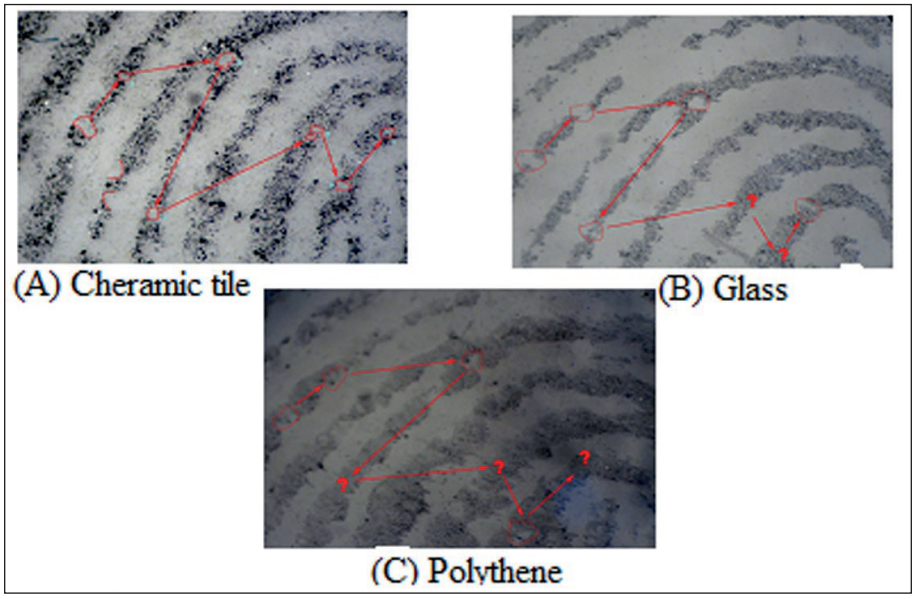

Figure 4: Relative positioning of pores in fingerprint developed by Powdering on (A) Ceramic tile (B) Glass (C) Polythene

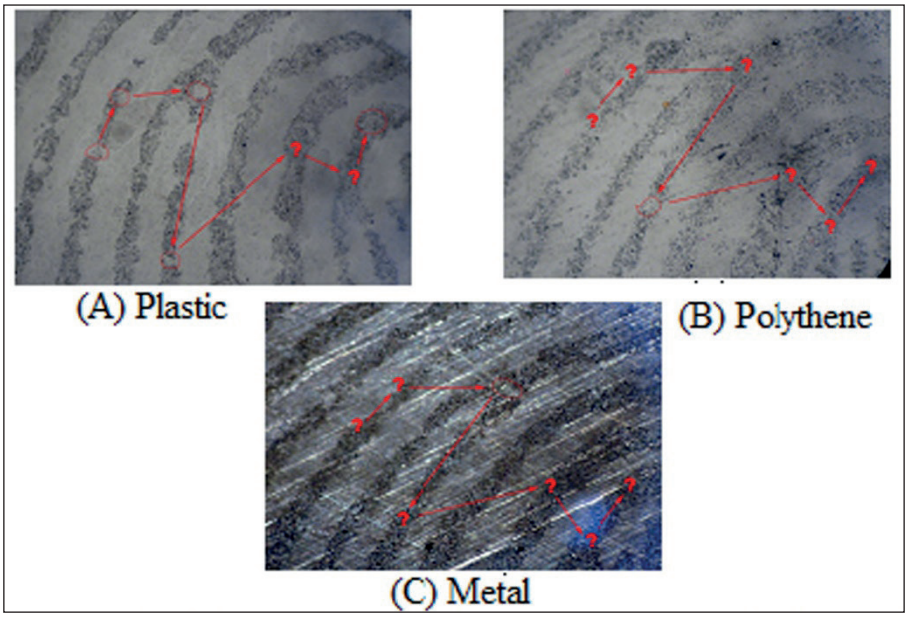

Figure 5: Relative positioning of pores in fingerprint developed by Small Particle Reagent (SPR) on (A)Plastic (B) Polythene (C) Metal

Pore visibility was minimal in cases of ninhydrin developed finger prints on paper. Porosity of surfaces like paper might have further contributed to decreased pore visibility. Filling of pores with development material was found to be significant in case of powdering and small particle reagent. Overall, pore visibility in fatty acid sensitive (physical) techniques was observed to be better as compared to the ninhydrin method. Similar findings concerning pore visibility in latent prints developed on various surfaces, by different methods, were reported by Jasuja (2006). Figure 6 shows how eccrine latent finger marks from same finger on different cartridges were developed with Cyanoacrylate and given post treatment subsequently with Rhodamine 6G show variable spatial positions.

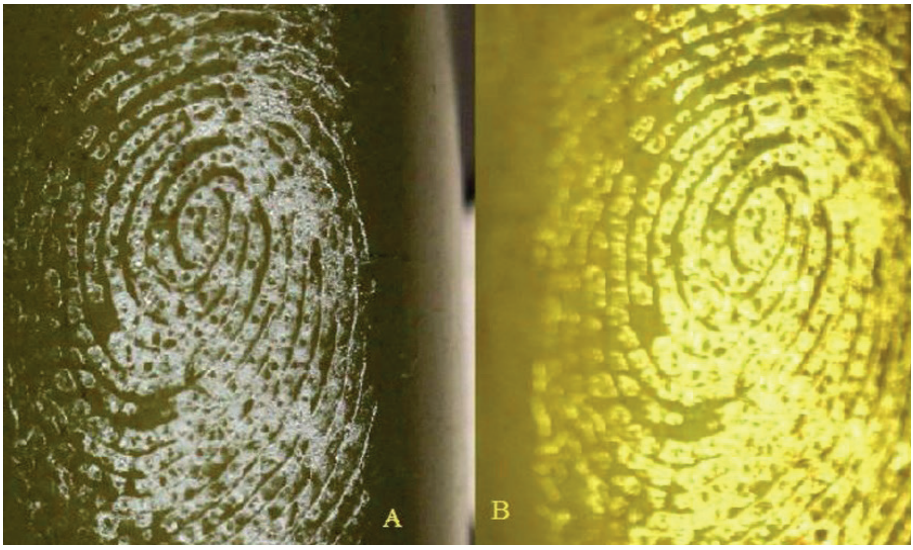

Figure 6: Ecrine latent print on colored steel metal surface: (A) Cyanoacrilate treatment (B) Post cyanoacrilate treatment with Rhodamine 6G (>25 pores)

It clearly indicates that same pores may not be represented in another mark of the same finger when treated differently. Eccrine prints consisted more than 8 characteristics from second level and at least 25 pores that presented excellent quality and quantity for identification. The optimum number of pores required for a definite finding, in absence of sufficient level II detail, is seven. Even this number of pores could not be found in latent marks that were consistently reproducing themselves using different methods from different surfaces (Parsons et. al., 2008). The results of the present work are in accordance with Parsons *et al.* (2008) findings.

D) Our next aim was to study different sets of fingerprints having similar and corresponding level II details but showing different pore configuration on papillary ridges. Individuality of fingerprints is a very critical issue raised in different practical cases like the case of the Madrid train bombings. Su and Srihari (2010) in context of Madrid Bomb case described the probability of finding at least one fingerprint in the FBI IAFIS databases (which exceeds over 470 million fingerprints); matches from the bomb site latent was 0.93 which is very high in terms of inaccurate identification.

While going through the AFIS database in the fingerprint bureau, we could also find more than one fingerprint that was different from another but having many level II details present at the same correlative position. Practically speaking, in case of latent finger mark development cases, where most of the marks are not complete or are smudged, the chances of having very few level II details are high. Therefore, it might be possible that some of the marks may be at the same correlative position leading to wrong conclusions. In such cases, if pore characteristics can be determined then latent print comparisons can result in more definitive conclusions. Accordingly, study of prints (inked as well as Live Scan) which are from different fingers but having level II details at the same correlative positions, were undertaken to determine pore configuration in ridge area in order to prove the significance of pore comparisons. A large number of prints were scrutinized from AFIS records for those prints having similarities in level II details (results are depicted in figure 7 and figure 8).

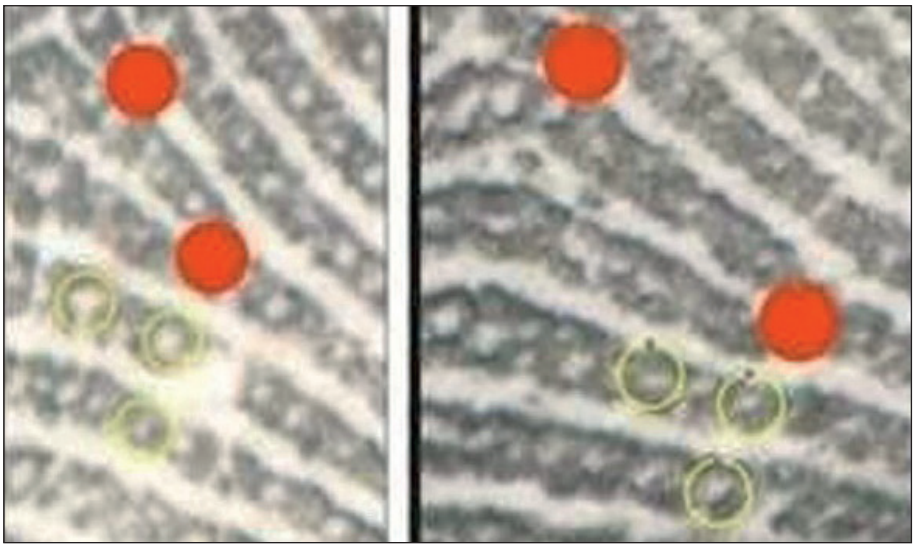

Figure 7: Comparative analysis shows non-identical samples where red spots denote second level characteristics match and the yellow circles denote the pores that are identical in accordance with the spatial arrangement

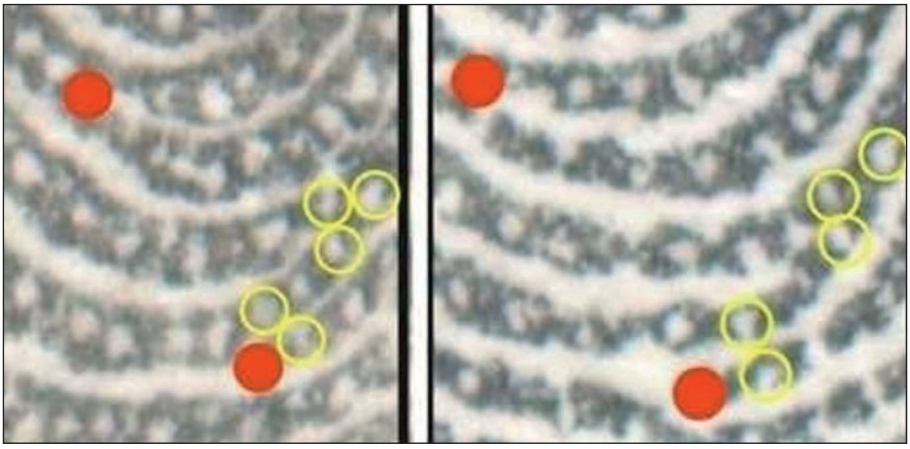

Figure 8: Comparative analysis shows non-identical samples where red spots denote second level characteristics match and the yellow circles denote the pores that are identical in accordance with the spatial arrangement

As evident from these figures, it is clear that there were a good number of prints from different fingers where we could find similar types of the level II details at the same corresponding position. Such findings could lead to an erroneous identification, which could be avoided through analysis of pore patterns on partial or small part of ridges. This finding clearly indicates that pores, if present in sufficient number, can assist in latent print identity even if the level II details are confusing or lead to erroneous conclusions. The relationship between minutiae and pores, as well as their joint use, has been described by Oklevski (2012, pp.161-163).

Conclusions

The present study was undertaken to generate findings concerning the forensic uses of level III details in the form of sweat pore openings, popularly known as poroscopy. Four aspects of poroscopy were studied. First, pores are always present in inked as well as livescanned fingerprints, but the quantity and quality of visible pores were found to be greater in live scanned prints, i.e., consistency in pores presentation on the ridges was better than in inked finger prints. Second, live scanned print consistency remained throughout the period of study when prints of the same finger were obtained at one hour intervals over an eight-hour period; this was not the case for inked prints. Third, there was no consistency in the presentation of pores in latent fingerprints collected from different surfaces. Fourth, the presentation of pores in latent fingerprints varied considerably when developed via different methods like ninhydrin, VRS and cyanoacrylate. Awa-

reness of the findings of this study will contribute to a greater understanding of the value of poroscopy in the identification of fingerprints, especially in circumstances when prints are partial or smudged with just a few ridges available for comparison. In addition to assisting in the accurate identification of fingerprint, of equal importance is the fact that poroscopy can also be utilized to prevent the inaccurate identification of prints, especially in cases with insufficient level two details in prints. These findings definitely will assist investigators to determine the role of horoscopy in personal identification.

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