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Comparison between fingerprints of the epidermis and dermis: Perspectives in the identifying of corpses

Leila Lopes Mizokami [a], Lara Rosana Vieira Silva [a], Selma Aparecida Souza Kückelhaus [b,*]

[a] Identification Institute, Civil Police of the Federal District, SAI Sudoeste, Bloco A, Ed. Sede, Brasilia 70610-200, Federal District, Brazil
[b] Area of Morphology, Faculty of Medicine, University of Brasilia, Campus Darcy Ribeiro, Brasilia 70910-000, Federal District, Brazil

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ABSTRACT

In forensic science, the putrefaction, maceration, mummification or burning make it difficult to collect the fingerprints of the epidermis for identification purposes. In such cases, the comparison between fingerprints collected from the dermal surface and the ante mortem pattern of the epidermal surface archived in databases must be performed. Therefore, considering that the identification of corpses is done by comparison of fingerprints on different surfaces, this study aimed to compare the epidermal and the dermal fingerprints to determine the discrepancies between the minutiae of both surfaces. The study was conducted with excised fingers of 19 fresh adult corpses. Once selected, excised and photographed, the fingers were subjected to maceration with 0.5% acetic acid solution for the removal of the epidermal glove and for registering the dermal fingerprint. Then, an area of 1 cm^2 in the epidermal and dermal photographies was selected and the minutiae of each were separately marked by an expert in identification. The comparison between minutiae of the epidermal and dermal surfaces showed that: (1) both surfaces maintained the patterns and characteristics of fingerprints (arch, whorl or loop) and the characteristics related to the systems and the disposal of the lines, meaning the formation or not of deltas; (2) the total number of marked minutiae did not differ between both surfaces for the group of individuals (paired t test, $p = 0.48$); (3) the percentage of coincidences and divergences (minutiae present on only one surface) between minutiae were $63.0 \pm 20.0\%$ and $37.0 \pm 20.0\%$, respectively; (4) identification was possible for 16 fingers/individuals, but not for 3 of them; (5) the increase in the number of marked minutiae does not affect the percentage of coincidences. Our results demonstrate the feasibility of the dermal surface for identification purposes due to the high percentage of matching minutiae, but considering the discrepancies and the inconclusive identification of 3 fingers/individuals, our study points to the use of more fingers per individual, as well as the possibility of further studies to improve on the techniques for increasing the identification of corpses, or even to deploy new technologies to ensure their rapid and safe identification.

1. Introduction

In forensic science, the identification of corpses may be difficult due to damage to the skin caused by the putrefaction, maceration, mummification or burning [1,2]. In such cases, the dermatoglyphics on the dermal surface obtained by chemical exposure are considered for identification purposes [1]. This method allows the comparison between fingerprints collected from different surfaces, the epidermal pattern formed by friction ridges, which remains archived in official databases, and the dermal fingerprint formed by the dermal papillae arrangement [3].

The study of Plotnick and Pinkus [3] showed similarities between minutiae identified in the epidermis and dermis of a single finger, furthermore, they described the dermis lines as narrower than those of the epidermis and that the dermal papillae are arranged in double rows. Later, other studies have suggested that the arrangement of the dermal papillae in the fingertips is variable and increases in complexity with aging [4,5] and that older people appear to have a higher number of interpapillary lines [6]. These findings suggest that morphological changes in the tissues of the skin may affect the pattern of the dermal papillae, due to the processes of tissue remodeling throughout life.

* Corresponding author. Tel.: +55 61 31071925.
E-mail addresses: leilamizokami@gmail.com (L.L. Mizokami), lararosana@hotmail.com (L.R.V. Silva), selmask@gmail.com, selmak@unb.br (S.A.S. Kückelhaus).

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It is known that the comparison between dermal and epidermal fingerprints show coincidences that are effective for human identification [7], but they can also reveal discrepancies that often lead to a reduction in the effectiveness of the identification process and drive the expert to an inconclusive result. These aspects show the importance of studies that demonstrate the presence of these discrepancies and that elucidate on how, and to what extent, the structural changes in the skin of the fingertip can affect human identification. Therefore, this study aimed to compare the fingerprints of the dermis and the epidermis of corpses to determine the coincidences and discrepancies between the minutiae of both surfaces.

2. Materials and methods

2.1. Individuals

The study was performed on excised fingers of 19 recently deceased unidentified corpses (16 men and 3 women) and taken to the Institute of Legal Medicine. To describe the epidemiological profile of the individuals, data from reports of cadaveric examination (gender, weight, height, date of death, date of removal to the Institute of Legal Medicine Leonídio Ribeiro of the Civil Police of the Federal District (IMLLR/PCDF) and cause of death were collected. The subjects were kept in the fridge (−10 °C) until the beginning of the study.

This study was conducted under authorization of the Civil Police of the Federal District and was in accordance with the Helsinki Declaration of the World Medical Association [8], which regulates research involving human beings. The study was approved by the Ethics Research Committee (Protocol No. 65/2011) and has no conflict of interest.

2.2. Selection, excision and registration of fingerprints

The selection of the most unspoilt edge between indicators and middle fingers, of both hands, was based on the analysis of the quality of digital design on the surface of the epidermis of the finger and by the similarity of its dimensions. After selecting a fingertip/individual, its extremity was excised in the region between the head of the proximal phalanx and the base of the middle phalanx (7 right indicators, 8 left indicators, 3 medium, 1 left middle). To register the fingerprints of the epidermis, the fingertips were photographed (Camera Nikon D60®, Lens Nikon Micro Nikkor 60 mm 1:2.8 D, resolution of 5.6 megapixels) with a source of indirect and mobile white light, in automatic scene mode, during which the camera remained fixed on the support 13 cm distant from the surface on which fingertips were on.

2.3. Exposure of the dermal surface

For exposure of the dermal surface, the excised fingertips were immersed and maintained in 100 mL of acetic acid 0.5% at room temperature until the full removal of the epidermal glove (8.3 ± 6.0 days), based on the study of Plotnick and Pinkus [3]. The verification of this detachment was performed every 24 h, and then the fingertips were immersed in 1.0% of toluidine blue for 1 h [9], washed in running water for 10 s to remove the excess dye, dried with an absorbent paper towel and photographed (Nikon D60 Camera®) for dermal fingerprint registration.

2.4. Identification and minutiae matching

For matching the minutiae, the fingerprint images of the epidermis and dermis were enlarged, calibrated based on photographic scale and rotated by the aligning of two minutiae (CorelDRAW® X6); an area of 1 cm^2 prioritizing the region with the highest number of visible lines and with preserved characteristics of the fingertips was selected. Then, the images were taken to a specialist who divided the area into nine quadrants for easy location and marking of the minutiae; this expert was unaware of the correspondence of the fingerprints. The minutiae were identified and numbered with two digits, the first to identify the individual and the second the minutiae; each minutiae identified on the image of the epidermis received the same number of its equivalent in the image of the dermis. Discrepant minutiae were marked once, on the epidermis or on the dermis fingerprint.

For comparison of epidermal and dermal fingerprints, another expert in fingerprints selected from among the nine (9) quarters those with clear drawings on both surfaces; quadrants with indistinguishable or distorted lines in at least one of the images were not analyzed. To facilitate comparison, a spreadsheet was created to check the correspondence between minutiae on the images of the epidermis and dermis, where the number 1 (one) was used when the minutiae were present in both images and the number 0 (zero) when they were absent.

2.5. Statistical analysis

The normality of variables was analyzed by the Kolmogorov–Smirnov test and the homogeneity of variances by the Barttlet test. In order to compare two groups with normal distribution the paired *t*-test was used and to compare more than two groups with non-parametric distribution, the Kruskal–Wallis test was used. Differences with a two-tail value of $p < 0.05$ were considered statistically significant, with a confidence interval of 95%. The Prism® software package (GraphPad, USA) was employed for statistical tests and graphical representation of the results.

3. Results

This study compared the epidermal and the dermal fingerprints of 19 adult corpses to determine the coincidences and discrepancies between the minutiae of both surfaces. The profile of the individuals is shown in Table 1.

Qualitatively, both surfaces allowed the identification of the fingerprint patterns (arch, loop or whorl) and maintained the characteristics related to the systems and the disposal of the lines in the formation or not of the deltas. When compared, both fingerprints showed that the number of minutiae did not differ between epidermis (14.4 ± 5.3) and dermis (15.1 ± 6.2) (paired *t* test; $p = 0.48$) (Table 2).

Identification was possible for 16 fingers/individuals (numbers 1, 2, 3, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18 and 19) by comparison of the minutiae in both fingerprints, but not for three of them (numbers 4, 5 and 12), due to the small amount of minutiae marked for the finger/individual 4 (7 minutiae/epidermis and 5/dermis) and due to the high percentage of discrepant minutiae found in fingers of individuals 5 (70%, finger/loop pattern) and 12 (84.6%, finger/whorl pattern) (Fig. 1).

As a group, the comparison of the dermal with their corresponding epidermal fingerprints showed a 63.0 ± 20.0% coincidence between minutiae and 37.0 ± 20.0% discrepancies (minutiae present on only one surface), as exemplified in Fig. 2.

To know if the increase in the number of marked minutiae could increase the percentage of coincidences, the fingers/individuals that matched were grouped into three classes (9–16, 16–22 or 23–29) and the percentages of coincidences were determined. The results showed that increasing the number of minutiae does not affect the percentage of coincidences of 68.3%, 71.7% or 61.6% for the three classes of minutiae 9–16, 16–22 or 23–29, respectively (Kruskal–Wallis, $p = 0.68$) (Fig. 3).