Julie B. Kempton,[1] M.S., M.F.S.; Amy Sirignano,[1] M.F.S.; Douglas H. DeGaetano,[2] M.S.; Paula J. Yates,[3] B.S., and Walter F. Rowe,[1] Ph.D.

Comparison of Fingernail Striation Patterns in Identical Twins

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ABSTRACT: The fingernail ridge patterns of a pair of identical twins were compared to each other, their parents, and an unrelated subject. The patterns of the twins' nails showed regions of strong similarity but were distinguishable from one another. Fewer similarities were found when comparing the nails to those of the parents and the unrelated control. The twins were shown to be monozygotic by means of DNA profiling. This therefore represents the first demonstration of unique fingernail ridge patterns in subjects shown conclusively to be identical twins. When the fingernail ridge patterns were examined with a scanning electron microscope, the backscattered electron (BEI) images were found to have superior contrast when compared to the secondary electron (SEI) images.

KEYWORDS: forensic science, fingernail striation patterns, identical twins

The use of nail striations as a means of personal identification has been investigated by a number of researchers in the past several decades [*1–10*]. Human fingernails and toenails contain longitudinal striations on both their upper and lower surfaces. These ridges are easily observed on the upper (convex) nail surface, but are more pronounced on the lower (concave) surface where they are protected from random abrasion. The striations are produced when keratinized nail is formed from epidermal cells at the nail base. There are parallel dermal ridges apparently distributed randomly beneath the nail bed, similar in structure to the dermal papillae which underlie the friction ridges on the fingers, palms, toes and soles of the feet. As the nail is extruded along these striations, it acquires ridges corresponding to the dermal ridges below it [*3*].

In some respects fingernail ridge patterns would be superior to fingerprints for identification because the nail's hardened structure is more resistant to decomposition and environmental effects such as fire. Forensically, however, fingernails are not likely to be as useful as fingerprints for identification because nails are not found at crime scenes as frequently as fingerprints. Nevertheless, nails are sometimes found in connection with crimes, particularly assaults, and may be very important in associating a suspect with the scene of a crime or with a victim.

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[1]Graduate students and Professor, respectively, Department of Forensic Sciences, The George Washington University, Washington, DC.

[2]Coordinator, Division of Forensic Sciences, Scientific Laboratories, Inc., Richmond, VA.

[3]Cellmark Diagnostics, Germantown, MD.

In order to be used as a means of personal identification, fingernail ridge patterns must be unique to each individual and must not be significantly altered with time (assuming there is no serious trauma to the nail) [*2,3,6*]. Fingernail ridges may become more prominent with age, but the striation patterns appear to be otherwise unaffected by the passage of time. It is believed that nail striations, having similar anatomical determinants as fingerprints, are therefore as persistent as fingerprints over time.

The question of uniqueness of fingernail striations has also been addressed in previous studies. Several researchers have looked in particular at the nail patterns of individuals believed to be identical twins. These studies have suggested that the ridge patterns are unique and easily distinguishable even between individuals with identical genetic make-up. In these studies, monozygosity of the subjects was tentatively established by self-ascription [*4,6,9*], by anthropometric measurements [*5*], or by blood typing in six blood grouping systems [*10*].

In this work, we have looked at nail striation patterns of twin subjects whose monozygosity was established using DNA profiling. Nail specimens from their parents and from an unrelated individual were also compared to the twins' nails in order to assess the degree of genetic determination in the patterns.

Materials and Methods

DNA Profiling

Blood samples were taken from the identical twin subjects for DNA analysis. Analyses were performed at Cellmark Diagnostics, Germantown, MD. In accordance with the proprietary procedure (Imperial Chemical Industries, SOP No. GTB001.) followed by the laboratory in paternity testing, the fluid blood samples were frozen to hemolyze the red blood cells. The leucocyte fraction of each sample was then pelleted with a high-speed centrifuge and washed with saline sodium citrate solution. The leucocyte fractions of each sample were digested in sodium dodecyl sulfate solution with proteinase K at 56°C for 1 h. After incubation each sample was extracted with phenol/chloroform (50:50). High molecular weight DNA was precipitated using absolute ethanol and washed with 80% ethanol. The purified DNA was restricted using Hind I. The restriction fragments were separated by electrophoresis in 0.7% agarose gel. The electrophoretic separation was carried out at a voltage of 75 V and a current of 50 to 60 mA; the separation required 18 h 50 min (corresponding to a 20 cm migration distance). Replicate samples of the twins' DNA were run on each gel. Two 1 kb size ladders, two samples of bacteriophage λ DNA restricted with Hind III and a control sample of human DNA were run along with the DNA samples being compared. The DNA fragments were transferred to nylon membranes using the Southern blotting procedure. The membranes were hybridized with two multilocus probes (33.15 and 33.6) and a cocktail containing four single locus probes (MS1, MS31, MS43 and g3). Autoradiographs of the membranes probed with each of the multilocus probes and the single-locus cocktail were exposed.

Preparation of Fingernails

Full-width fingernail clippings were obtained from 22-year-old, Caucasian, female, identical twins, their parents, and an unrelated control subject. Each clipping was placed in a capped plastic tube and labeled according to the finger it was taken from. Nails were flattened by clamping them between microscope slides for seven days. In order to improve definition of the ridges for microscopic examination, the nails were coated with a thin (approximately 300 Å) layer of gold using an EMSCOPE SC 500 gold sputter coating unit. The nails were coated for seven minutes at a current of 35 mA with a distance to sample equal to 40 mm.

Microscopic Examinations

The nails were compared microscopically using an American Optical Corporation UFM-2 Forensic Microscope (Model K2031A) equipped with 1.2×, 2× and 4× objectives and a fiber optic illuminator. Difficulties were experienced in obtaining photomicrographs of the full widths of the fingernail clippings using the comparison microscope. The slight curvature of the flattened nails, combined with the limited depths of field of the objectives of the comparison microscope, prevented the obtaining of sharply focused photographs with the comparison microscope's camera attachment. Consequently, the nails were examined and photographed using a CamScan Series II scanning electron microscope equipped with a Robinson backscattered electron detector. Both secondary electron (SEI) images and backscattered electron (BEI) images of the nails were obtained.

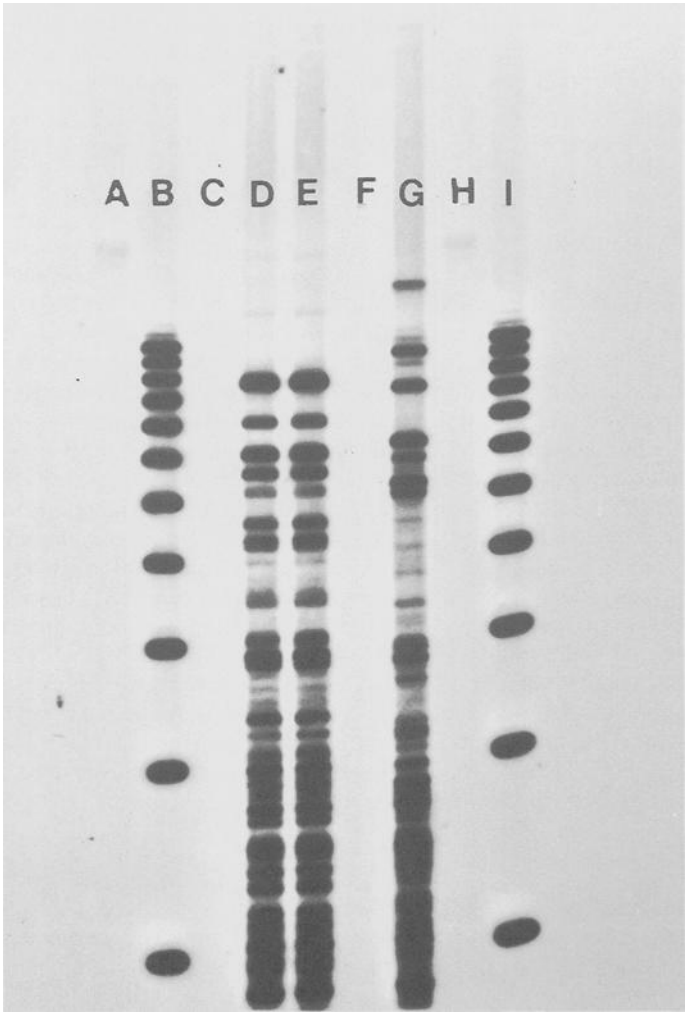

FIG. 1—*Autoradiograph of nylon membrane probed with multilocus probe 33.15. Lane A: Bacteriophage λ DNA restricted with Hind III; Lane B: 1 kb size ladder; Lane C: Blank; Lane D: DNA from Twin AS; Lane E: DNA from Twin CS; Lane F: Blank; Lane G: human DNA control; Lane H: Bacteriophage λ DNA digested with Hind III; Lane I: 1 kb size ladder.*

Results and Discussion

The DNA profiling demonstrated unambiguously that the subjects are in fact monozygotic. Figure 1 shows the autoradiograph obtained with the multilocus probe 33.15, while Fig. 2 shows the autoradiograph obtained with the single locus probe cocktail. The autoradiographs show a complete correspondence of bands between the two individuals.

The striation patterns of each fingernail were compared with all ten fingernails of the other twin. The nails were moved back and forth relative to each other to find the best possible match of striations. The twins' fingernail were found to have regions of similarity but the overall patterns did not match. The fingernails from corresponding fingers were most similar. Figures 3 to 5 show comparisons of backscattered electron scanning electron

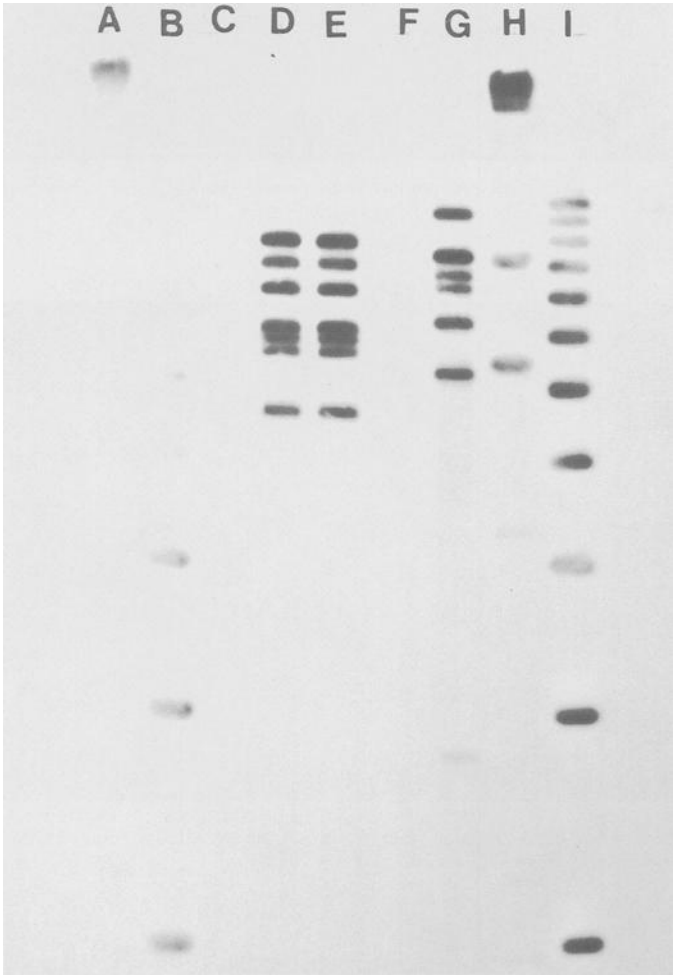

FIG. 2—*Autoradiograph of nylon membrane probed with single-locus probe cocktail (MS1, MS31, MS43 and g3). Lane A: Bacteriophage λ DNA restricted with Hind III; Lane B: 1 kb size ladder; Lane C: Blank; Lane D: DNA from Twin AS; Lane E: DNA from Twin CS; Lane F: Blank; Lane G: human DNA control; Lane H: Bacteriophage λ DNA digested with Hind III; Lane I: 1 kb size ladder.*

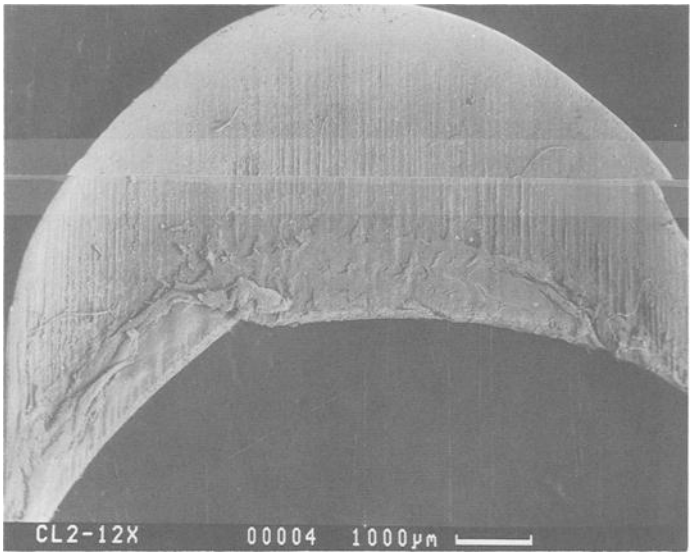

FIG. 3—*Comparison of backscattered electron scanning electron micrographs of ridge patterns on left index fingers of twins. Backscattered electron images.*

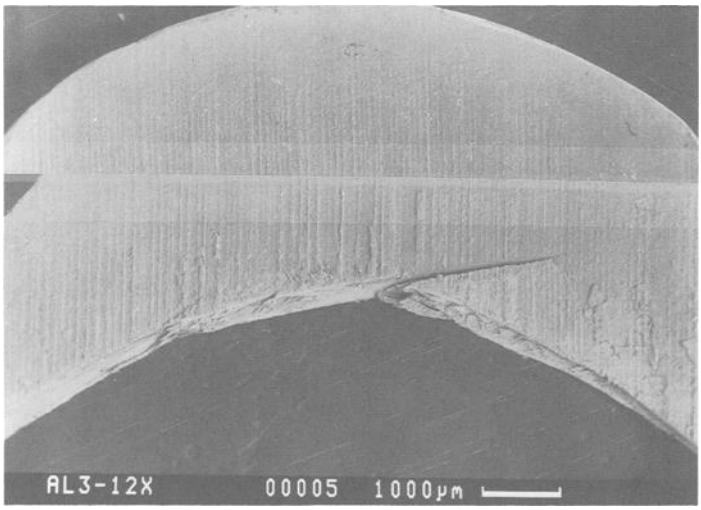

FIG. 4—*Comparison of backscattered electron scanning electron micrographs of ridge patterns on left middle fingers of twins. Backscattered electron images.*

micrographs of the ridge patterns of fingernail clippings from corresponding fingers. The fingernail ridge patterns of one twin were readily distinguishable from those of the other. Comparisons of the twins' nail patterns with those of the parents and the unrelated subject did not show significant similarities.

Additional comparisons of the twins' fingernail ridge patterns were also made. The ridge patterns on the fingernails of the left hands of one twin were compared with those

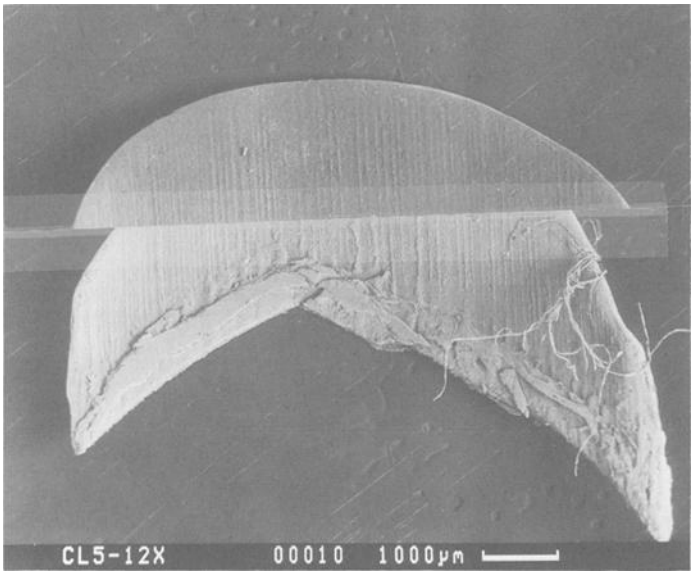

FIG. 5—*Comparison of backscattered electron scanning electron micrographs of ridge patterns on left little fingers of twins. Backscattered electron images.*

on the corresponding fingernails from the right hand of the other twin in order to determine if the fingernail ridge patterns exhibited bilateral (that is, mirror-image) symmetry. Such bilateral symmetry has been observed and commented upon in the case of twin fingerprint patterns. In this case, no bilateral symmetry was found in the fingernail ridge patterns.

SEI and BEI images of the same nail clipping are shown in Fig. 6. The BEI image

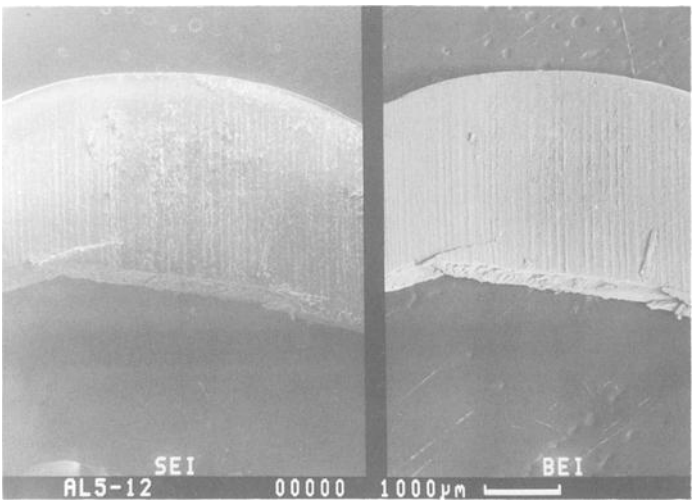

FIG. 6—*Secondary electron image (SEI) and backscattered electron image (BEI) of the same fingernail clipping.*

shows the nail's ridge pattern with better contrast. Such images would more useful when fingernail ridge patterns are compared using a scanning electron microscope. The principal element contributing to the back scattering of the electron beam of the electron microscope is the sulfur in the keratin of the fingernail. The thicker portions of the nail scatter more of the electrons in the electron beam backwards due to the larger number of sulfur atoms in the beam path; the thicker regions of the nail consequently appear brighter in the BEI image.

Summary

The fingernail ridge patterns of a pair of identical twins were compared to each other, their parents, and an unrelated subject. The patterns of the twins' nails showed regions of strong similarity but were definitely distinguishable. Fewer similarities were found when comparing the nails to those of the parents and the unrelated control. The twins were shown to be monozygotic by means of DNA profiling. This therefore represents the first demonstration of unique fingernail ridge patterns in subjects known to be identical twins. When the fingernail ridge patterns were examined with a scanning electron microscope, the backscattered electron (BEI) images were found to have superior contrast when compared to the secondary electron (SEI) images.

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Address requests for reprints or additional information to
Walter F. Rowe, Ph.D.
Department of Forensic Sciences
The George Washington University
Washington, D.C. 20052