Review on the Individual Identification of Human Hair Morphology for Retrospect and Prospect

Abstract In 1837, Brewster optical microscope for the first time the specificity of the surface structure of hair was found. With several new technologies in practice the application of the morphological structure of the hair, the gradual deepening, hair morphology of research results are widely used in the field of individual identification of forensic science, in some developed countries for individual identification of hair has become a fixed the guiding principles and application guidelines. In recent years, with the high-tech developments, such as atomic force microscope and other applications, morphological structure of hair into the micro-, ultra-micro-level, and conducted quantitative research, which makes the hair on the validity of the identification of individual identification was confirmed. In this paper, the individual identification of hair morphology of research progress at home and abroad are reviewed.

Keywords: Forensic science; Individual identification; Human hair; Morphology; Review;

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1. The basic structure of human hair morphology

Of human hair into long hair (hair, beard, armpit, pubic hair), Short-haired (eyelashes, eyebrows, nose hair, ear canal Short-haired), vellus hair, lanugo 4. Short-haired long-haired, and the final synthesis of hair, is characterized by rough and hard, color and thick, with medulla and melanocytes. Vellus hair soft without the medulla, shorter, most no more than 2cm, can have lighter pigments, are found in addition to the Ministry of palms and soles, vermilion, nipples, glans penis, clitoris and finger (toe) Distal outside the body. Lanugo soft, thin, no pigment, no medulla. In humans, hair growth and replacement is through a growth phase (active phase) (anagen), transitional phase (catagen) (catagen) and resting stage (telogen) continuous process [1]. Final hair by hair shaft, hair root, hair follicles (1) medulla: is located in the center of hair is determined by loosely arranged polygonal marrow cellularity; the arrangement and the present pattern due to the different types of hair while a wide range of performance, the role of a classification. (2) hair cortex: is a close parallel to the longitudinal axis with the hair arranged in long, slender spindle cells. (3) hair cuticle (also known as flake): It is the most appearance of hair cover, the ground layer to the multi-storey flat keratinized cells in a transparent composition, was coronal, petal-like, corrugated-shaped surface such as a variety of form [2]. The end of the hair root enlargement was spherical, that hair bulb. The microstructure of hair depends primarily on congenital, with species-specific; the same time, due to function and adapt to the same or different, will also show the corresponding general character and individuality. So that the microstructure of hair to show complexity.

2. Individual recognition of human hair

The 20th century, 20 to 30 years, with optical microscope based on morphological structure of the first phase of the hair. In 1920, the United States issued a mammal Hausman coat of micro-features, the first time that the microstructure of the existence of gross differences between species, there has been Taxonomic Significance. And the hair is divided into three ethnic groups (Caucasian whites, blacks, Mongolians), etc.. Trotter, M study of this period in different age, sex, ethnic characteristics of beard; white Americans, the French, Canadians, Iraq and the Arabs hair characteristics. Application of research results began to criminal investigation. This period of

preparation method of a number of hair samples also gradually improved. The 20th century, 40 ~ 90 years, especially 70 years or so, the application of electron microscopy, the hair on the whole body multi-angle, multi-level, a study [3], such as different ages, different sexes, different parts of the difference between the hair. But these details of the research results transferred to the forensic practice, no system coverage. There are research reports of hair identification of possible deviations in [4]. In 1982, the United States was established by Barry Gaudette Chairman of forensic science hair test evaluation committee [5], so that this stage of identification and appraisal of individual hair peaked. In 1991, Teerink published in "Hair of West European Mammals" book is about the hair, the most systematic study of the writings, systematically expounded the species identification of hair, the principles, methods and should pay attention to the problems [6].

The past 20 years, is the third phase of the study of hair, this time due to the extensive application of molecular biology techniques, many scholars turned to the study of hair, DNA and mtDNA. But the novel nano-high-resolution microscopes, such as atomic force microscope (AFM), micro-diffraction techniques applied to the micro world, the morphological structure of hair gradually to a deeper mystery of space development. In 1986, Binnig and Rohrer invented scanning tunneling microscope (STM) and atomic force microscope (AFM). In recent years, STM and AFM have been in the life sciences, microelectronics and nano-technology and other fields has been widely used. Since 1994, the first reported study using AFM hair started [7], AFM is considered a non-invasive detection of the hair surface, the ideal technology, which provides greater clarity than the SEM and TEM images of the epidermis. Smith,JR step Smith, JR related software with the AFM images of the AFM quantitative, digital analysis, such as the hair of small skin-related data: the high step (step height), tilt angle (tilt), the dorsal angle (backtilt), spacing (layer spacing), surface distance (face distance), at the top of the distance (top distance), the error match (fit error), hair density of small skin (cuticle density), hardness (roughness) and matching ratio (fitability) measurements and calculations, and using least-squares method, cluster analysis, statistical analysis software, can the majority of samples (86%) were correctly classified [8]. AFM probe measurement area of $20 \times 20 \, \eta$ m of the plane, while the hair is round, a long linear structure. To be able to repeat the study of hair in the same location, reduce the position errors caused by round, some scholars studied the

correction factor [8], and adjust the scanning range, so that repeated AFM scans before and after the return to the same location [9]. Sato H [10] conducted a study of the Japanese hair that hair in the intra-individual variation between the small and individual variation, which is conducive to comparative morphology of hair done by personal identification. And get a great deal more on the hair morphology of large amounts of data, which will be conducive to the establishment of a hair test analysis system. Verma MS [11] demonstrated the use of such NNESs (neural network explanation systems) carried out the feasibility of personal identification of hair. The NNESs, simply enter the 21 micro-structural characteristics of the five, will be to determine whether the two from the same individual. Method has been applied can be done should be 83% of the match rate. Human hair has traditionally divided into three categories according to national characteristics, that is mentioned earlier, the Caucasus whites, blacks, Mongolians, with straight, wave, roll, knot, rotating the words name, but this does not apply the points system has been one the world's brings the situation. De la Mettrie R [12] without regard to race differences, the hair on the worldwide research carried out, with curly diameter, curl index, wave number and the number of targets circled, with the main component analysis software to the hair is divided into eight categories, which than the traditional classification by name more specific and accurate. Russian scientists studied dozens of countries on four continents hair micro-and macro-morphological characteristics, improve the knowledge base of the hair around the world.

In 2004, the U.S. court issued a scientific exchange on the hair analysis identification guides and operating manuals, including animal and human hair identification of two parts [13-14]. Application comparison microscope and the microscope right hair color race, hair little skin, cortex and medulla, hair dry, hair root, hair shaft shuttle, pigment granules type and physical characteristics of different parts of the hair comparison, and gives micrographs ; how to distinguish animal hair and human hair; people dealing with hair, such as bleaching, dyeing and other characteristics; cutting, shaving, smashing, burning and other external force upon the performance of the hair; the tools of regulation and sample preparation. Through the above indicators are known and unknown hair hair than the right, arrive at the same determined. The United States and identified specific hair McCrone company's responsible person Richard E Bisbing in 2007, to the Professional Committee of the Association

of Forensic Science presenting with hair than the standard, quality assurance, personnel training and requirements [15]. He referred to the inspection staff must receive at least a bachelor's degree in natural sciences and applied sciences; technical guidance must be related to a professional master's or Ph.D. and at least five years experience in trace evidence examination; or access to natural and Bachelor of Applied Science With a degree in the five-year examination of trace evidence examination of the experience, through the courts found that the legal procedures of science or a registered laboratory examinations, and advanced courses in the microscope to achieve good results before they can become a technical guidance. Pointed out that the identification of hair and test the effectiveness of work experience who have a direct relationship.

Domestically, the shape of the hair, and individual identification studies late in 1963, Mr. Peter published a China back hair first mammal research articles [16], followed by the hair, the study reported increased gradually. Foreign-based basic research, at the outset tend to application stage, such as mammals, the differences between the kinds of characteristics and identification. In 1983, Zhan re-million in the anatomy of the newspaper published her first normal hair and scanning electron microscope, began the study of human hair morphology, but only limited to the surface of gross morphological structure of small skin type, and is divided into six categories, for the observed differences between sex and age [17]. Later, China had more than a dozen research articles on hair shape, focusing on the study of Mao's little skin, trying to sort through the hair of small skin, studies have normal fetus, different nationalities, different parts of the hair-like surface morphology and longevity for the elderly hair characteristics, this paper has the shape of Mao's description of the small skin. These studies focused on the analysis of subtle form of clutter-type scales, while ignoring the causes of these scale forms, so it does not achieve the expected results. In 1988, Wang Wei and other various parts of the hair of normal adults, a small skin hair done morphometry studies, for hair in forensic science in personal identification applications can be found in the data. However, small sample size, not necessarily representative. Hsu Wen-Long [18] observed the 91 cross-sectional characteristics of Chinese human hair, including short track, long track, cross-sectional index and cross-sectional area, and with other ethnic groups were compared. Found that Chinese people the most coarse hair, cross-sectional shape, closer to the circular, the only long diameter was significantly smaller than

blacks, but also on the characteristics of the hair cross-section of gender differences and individual differences were analyzed. And based on the results of forensic tests in the morphology of hair put forward a preliminary comments. And in 1992, wrote "Hair testing and individual identification," explained hair morphology, structure, function, disease changes, which are detailed on hair testing a variety of techniques and methods of work, and proposed mechanism of hair damage insights. In 1998, Ding Min-Ju [19] using scanning electron microscopy of human hair tip micro-morphological characteristics, summarized several parts of the body hair tip the main form of the eight types: blunt-po head type, sub-again type, flush type, no scale type, oblique mouth, irregular type, needle type and conical; into different aspects of Tippy the possible shape of the formation conditions of regularity of the distribution, as well as the Ministry of pruning back-end changes, there is a great practical significance, for the hair adds an indicator than the right.

Into the 21st century, due to DNA and mtDNA testing in hair is widely used in individual identification, the morphology of hair and fewer and fewer reports of individual identification. There are several normal hair introduction of scanning electron microscopy features and changes in hair for adults of different ages, measuring the diameter of the hair, growth, density, etc., used to assess the population aging and health. There are a few disease-related changes in hair morphology reported [20], but it is also limited to gross morphological changes of the small skin. Hair in the forensic application and progress of the review, including with the hair all the relevant content, such as trace elements, organic compounds, biological testing (DNA, ABO blood type, protein, mtDNA, etc.) [21]. In recent years, national reports on hair is also focused on the content. Has published several books and hair-related [1,22], of which there are some elements, such as different ethnic groups, occupation, region, age, individual differences in trace elements in hair can be used to identify you personally.

The foregoing findings, the domestic research on hair late, and did not form a system of inspection and analysis of identification procedures. For the morphology studies confined to surface structure. Abroad on hair morphology studies have been deep into the nano-scale structure, and and practice, promoting a variety of disciplines. Individual Recognition of shape from the initial structure of a gradual shift of quantitative research, some scholars predict that, with in-depth study of hair in individual identification will play a greater role.

3. Individual identification of human hair morphology research prospects

Hair is the most accessible, most easily stored biological samples. Normal day, there are dozens to more than 100 natural shedding hair root, with the criminals, anti-detection capabilities, criminals to destroy the scene after committing the crime, destruction of physical evidence and other means to make the scene of many criminal cases, there may not be any other physical evidence left behind and only one or hairs, hair in the investigation of such cases becomes more important, the identification of hair the result will directly affect the investigation of cases.

3.1 The morphological structure of hair identification of individuals

Hair can come off naturally or by external factors which led to unnatural shedding. In the homicide, assault, rape or other criminal cases, since the parties between individuals directly or indirectly contact, scuffle, friction, weapon combat and so on, may make the offender or the victim's hair left at the scene, attached to the weapon or the victim's such as underwear and body parts, thus becoming the crime scene evidence. Hair detection of such trace evidence forensic examiner should be attention to study the shape of hair can be a number of important information (yes hair or textiles or other things, whether human hair, what type of animal, whether from false hair, that race, that the body parts, hair color, is broken pinched or cut, hair cut the way, if burnt, would have been bleached or dyed, is forced avulsion, whether derived from the suspect, whether to do DNA analysis, etc.), some information on DNA analysis is not available. The intrinsic characteristics of hair can be used to trace evidence such as hair constantly falling from the body, is evidence of a person's unique, hair easy to discover, can be used as evidence of permanent preservation, the hair contains the DNA and so on. These are other biological specimens difficult to achieve.

3.2 The establishment of specialized hair micro-structure, testing accreditation body

As opposed to DNA testing, micro-morphological evidence of hair was considered too subjective, the lack of scientific evidence and scientific rigor applied in the absence of established guidelines has been widely criticized. The reason leading to this result are manifold. One very important reason, or fails to recognize the importance of hair as evidence. NDNA and mtDNA analysis of hair can not be denied

the individual identification of the role, but also has its limitations: the hair found at the scene may be too much, to full analysis of DNA, will inevitably bring about unnecessary waste of resources; also have a lot of hair, can not be extracted to the DNA; mtDNA is maternally inherited, there are differences with the mother the possibility of the child; a lot of hair as evidence of the microscopic characteristics of DNA analysis can not be. Therefore, in DNA analysis techniques mature, it is necessary to re-establish the micro characteristics of the hair as evidence in confidence. But to get the court recognized, there must be a clear identification of the test criteria (such as: How to sampling and selection of materials, what tools or methods to test the eligibility certification, quality assurance testing to identify the validity of the results, etc.). The implementation and enforcement of these standards must be developed jointly by a senior expert, and to monitor implementation. At the same time, we must recognize the limitations of hair testing and the recognition of the uncertainty of test results, leading to uncertainty for many reasons: too few samples of known and unknown hair samples of hair similarities exist and can not explain the non-similarity has been Inspection of the microscopic hair samples do not have enough features (such as: fracture, fragment, short, colorless, fuzzy, etc.). Therefore, morphological examination of hair, DNA testing must be combined, in the identification of complement each other in order to maximize the potential of science to explore the value of the cases detected in the hair, will play an important role.

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