

Study on signature of hair for identification of two major ethnic groups

Abstract

Studies on hair have important forensic significance since hair is the most common type of physical evidence detected in crime like murder, rape, burglary even poaching related cases and other ways also. The examination of hair helps to establish the origin, race, sex, age etc. and also to link evidence in different crime cases. In the present study, an effort has been made to create a database of two ethnic groups considering various morphometric parameters of scalp hair using light microscopy, SEM as well as conventional methods. The database of two major groups (Caucasian and Mongolian) of the state Tripura, North-Eastern region of India, will help the researchers, forensic experts, biologists, dermatologists and legal experts working in different fields.

Keywords: hair, morphological, microscopic, SEM (scanning electron microscopy), race, sex, forensic evidence

Introduction

Hair is an epidermal derivative of mammalian skin that grows out from hair follicle. The shaft of hair is composed of three layers viz. cuticle, cortex and medulla.¹ The cuticle is the outer covering of the hair shaft composed of thin non-pigmented transparent scales which are attached with the cortex at their lower margins and its thickness is measured under different scales.² In the cortex, long keratinised fibrils are found arranged parallel to the shaft of hair and are surrounded by amorphous proteins known as matrix. Pigment distribution in the cortex also includes various characteristic patterns. In human hair, the pigment is usually distributed near the periphery, but also found uniformly along the length of the cortex.³ The medulla is the central core of the hair shaft. The diameters of medulla vary showing different characteristic features useful for the study.⁴

The medullary index measures the diameter of the medulla relative to the diameter of the hair shaft and is normally expressed as a fraction. In case of human, the index generally has a value less than 1/3; for most of the other animals, it is 1/2 even more. Further, presence and appearance of the medulla vary from individual to individual and even in hairs of the same person. Human scalp hair usually does not show any medulla or has fragmented ones. They rarely show continuous medullation; but exception is found among the Mongoloid race having continuous medullae on their scalp hair.¹

The study of hair has wide application in the following ways:¹⁻⁸

- Characterization of hair origin (human/animal)
- Determination of race/sex/site of body
- Serve as evidence against the criminal
- Serve to detect species of wild animal in poaching cases
- Disputed paternity/maternity issues from hair DNA (with root)
- Analysis of dye used for dying hair
- Elemental composition of hair to determine metal poisoning
- Congenital abnormalities
- Identification of smoker/non-smoker from hair study

- Difference between natural/synthetic hair/fiber
- Geographical parameters and environmental/physical/biological evidence
- Examination of textile materials (hair) used for knitting
- Detection of drug and abuse substance from hair

The objective of the present study is to create a database by comparing various morphometric parameters such as scale count, cuticle thickness, medullary index, scale margin, scale distance, scale pattern, shaft cross-section shape, pigment distribution of scalp hair of two ethnic groups (Caucasian and Mongolian) of the state Tripura, North-East India, to identify race, sex etc. from the sample hair of hundred donors.

Materials and methods

Samples of scalp hair were collected from volunteer students of University whose hair was not chemically treated (dyed, bleached, straightened). A total of 100 volunteer's scalp hair samples, each 25 from North-East Indian Caucasian male and female and each 25 from Mongolian male and female, were collected for the study. An average of 20 hair samples per individual were collected by pulling from different areas of head and packed in separate envelopes. All the hair samples collected from the donors were properly coded. Thereafter, the hair samples were treated with shampoo followed with repeated washing with distilled water for the study.

In order to observe cuticular pattern, a cast of hair was made on cellulose-acetate sheet using acetone soaked cotton. The impression of the scale pattern made on cellulose acetate sheet was observed under suitable magnification (100x-400x). The cross sections of hair samples were made using paraffin block and the cut sections were de-waxed using xylene. The prepared slides were observed under microscope (Leica DME, Germany). Medullary Index and scale count were measured using the following formulae:³

- (i) Medullary Index = Diameter of medulla/Total diameter of hair shaft.
- (ii) Scale count = Number of scale/100 micrometer length.

Results

The results of hair analysis on different parameters of both sexes of the two ethnic groups shown in Table 1 and Figures 1–10, are very much useful to differentiate hair samples for forensic examination and other purposes.

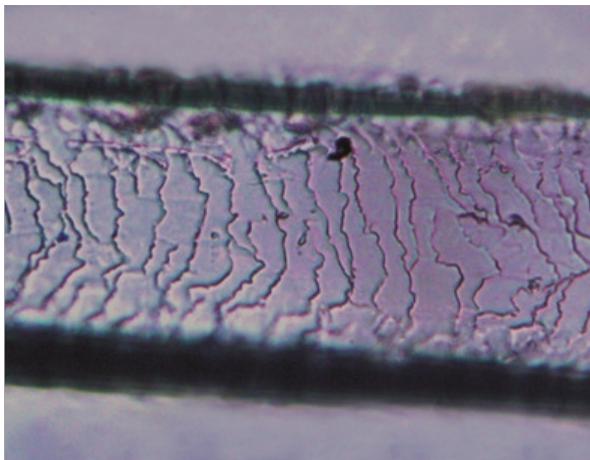


Figure 1 Crenate scale margin of scalp hair found in male individuals of both Caucasian and Mongolian races.

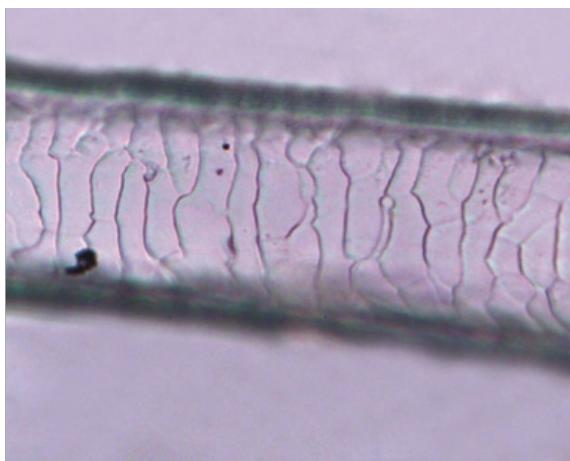


Figure 2 Smooth scale margin of scalp hair found in male and female individuals of both Caucasian and Mongolian races.



Figure 3 Oval cross section of scalp hair found in male individuals of both Caucasian and Mongolian races.

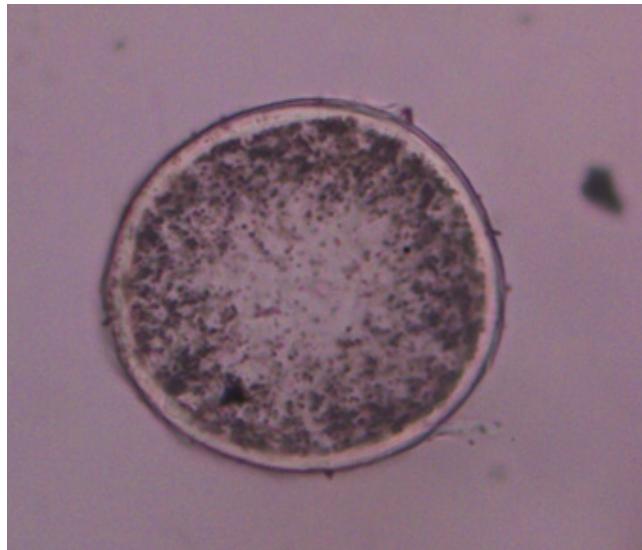


Figure 4 Round cross section of scalp hair found in male and female individuals of both Caucasian and Mongolian races.



Figure 5 Peripheral pigment distribution seen in scalp hair of most of the Caucasian and Mongolian races of both sexes.



Figure 6 Uniform pigment distribution seen in scalp hair of some of the Caucasian and Mongolian races of both sexes.

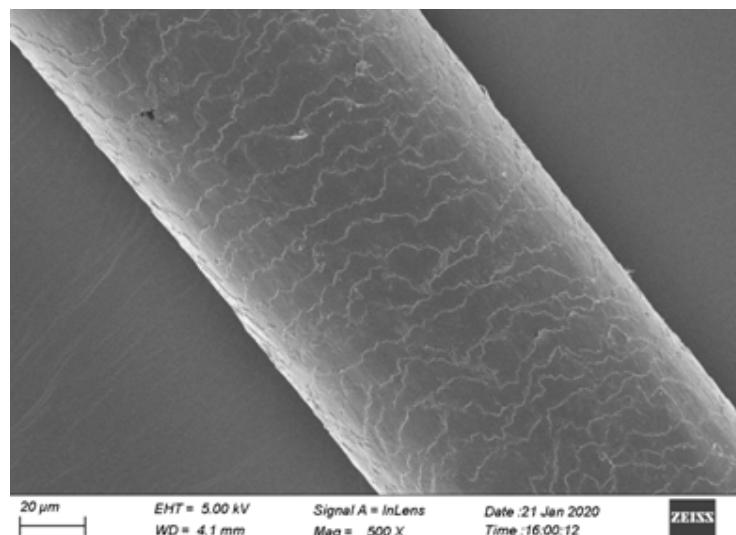


Figure 7 SEM view of scalp hair of Caucasian male showing pointed indentation of scale margin.

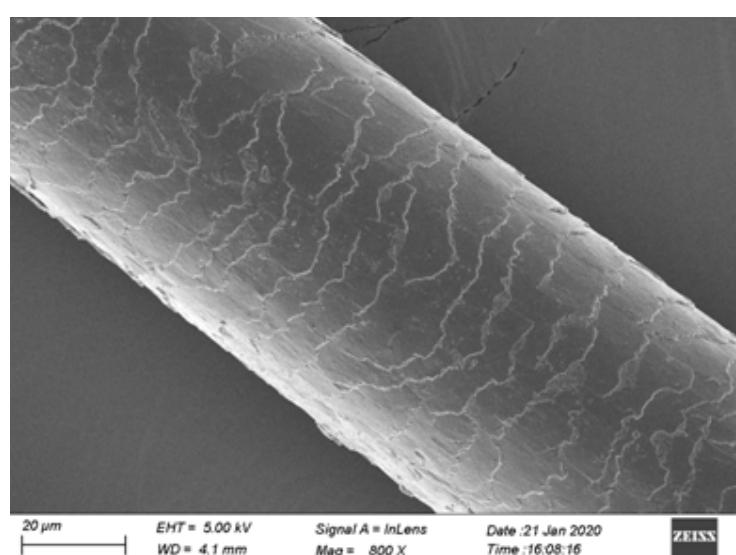


Figure 8 SEM view of scalp hair of Caucasian female showing blunt indentation of scale margin.

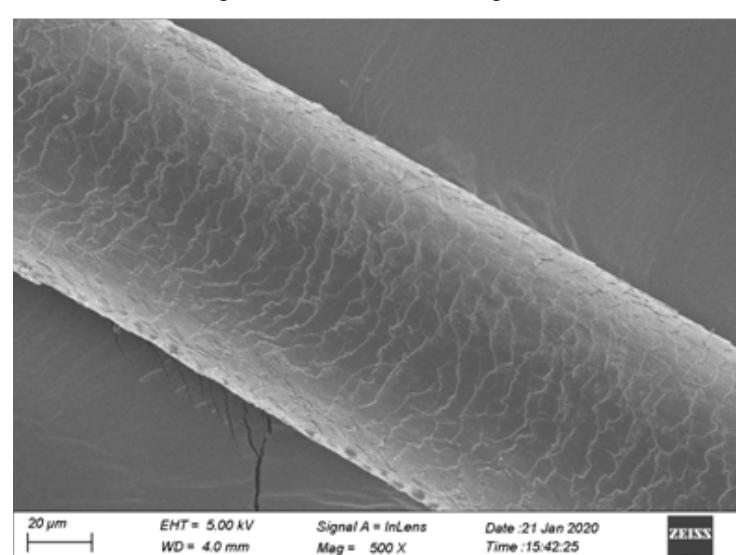


Figure 9 SEM view of scalp hair of Mongolian male showing pointed indentation of scale margin.

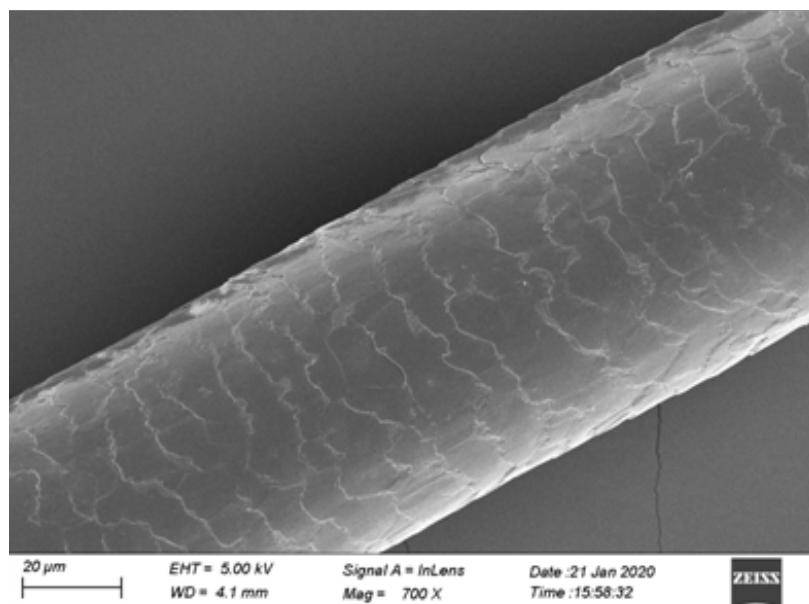


Figure 10 SEM view of scalp hair of Mongolian female showing blunt indentation of scale margin.

Table I Various morphometric parameters of scalp hair analysis from both sexes of the two racial categories

Parameters	Caucasian		Mongolian	
	Male	Female	Male	Female
Scale count (No)	202±2.64	202±4.08	210±3.03	212±2.85
Cuticle thickness (μm)	0.13±0.004	0.16±0.004	0.12±0.004	0.21±0.006
Medullary index	0.116±0.016	0.114±0.016	0.105±0.018	0.121±0.016
Scale margin	All crenate	Crenate=44% Smooth=56%	All crenate	Crenate=68% Smooth=32%
Scale distance	Near	Near	Near	Near
Scale pattern	Regular	Regular	Regular	Regular
Cross section shape	All oval	Oval=76% Round=24%	All oval	Oval=44% Round=56%
Pigment distribution	Peripheral=75% Uniform=25%	Peripheral=72% Uniform=28%	Peripheral=80% Uniform=20%	Peripheral=88% Uniform=12%

Discussion

Hair is one of the most important physical evidence encountered in a wide variety of crimes and play a crucial role in forensic investigation.^{5,6} Detection of hair at the crime scene is considered strong physical evidence against the criminal. Microscopic examination of hair helps to characterize its morphological features for identification of species and also reveals information about race, sex and site of body which is very useful to link the offender with the crime. Further studies on three different layers of hair like outer cuticle, inner medulla and intermediate cortex, are also helpful for hair characterization.⁷

In the present study, the results of cuticle thickness and scale count show some differences among individuals of both sexes of the two races. Similarly the results of scale margin and cross section shape reveal some variation between the two sexes of both the races, but there is no significant difference in the study of scale distance, scale pattern and medullary indices among the individuals of two racial categories. Besides, the other special characteristics like cosmetic treatment (dye,

bleach), structural abnormalities of the shaft etc. also provide very important clues in hair identification. All the features together provide useful discrimination whether a sample hair originates from a specific individual.⁸

Conclusion

In the present paper, studies on hair of two ethnic groups (Caucasian and Mongolian) with limited volunteers provides some distinguishing features for identification of race and sex and requires further study of a large number of inhabitants of the region to build a concrete database. The database of hair of both the groups would help the forensic experts, biologists, dermatologists, researchers and legal experts working in different fields.

Acknowledgments

The authors are thankful to the Professor in-charge of the Central Instrumentation Unit, Tripura University for extending support to conduct SEM study.

Conflicts of interest

The author declares there are no conflicts of interest.

References

1. Saferstein R. *Criminalistics - An Introduction to Forensic Science, Sixth Edition*, Prentice hall. 1998.
2. Ogle Robert R JR, Fox MJ. *Atlas of Human Hair: Microscopic Characteristics*. CRC Press, Boca Raton. 1999.
3. Nandy A. *Principles of Forensic Medicine*. 2 ed. 2000.
4. Modi JP. *A Text Book of Medical Jurisprudence and Toxicology*. 24 edn. 2011.
5. Nataraja Moorthy T, Roy Jessica Marie. Study on hair Morphology to Distinguish the Dominant Races in Malaysia for Forensic Investigation. *J Forensic Sci Criminol*. 2015;3(4):403.
6. Ahmed YA, Ali S, Ghallab A. Hair Histologyas a tool for Forensic Identification of some domestic animal species. *EXCLI Journal*. 2018;17:663–670.
7. Dahiya MS, Yadav SK. Elemental Composition of Hair and its role in Forensic Identification. 2013;2:721.
8. Guadette BD. *Evidential Value of Hair Examination*. In: Robertson J, editor. *Forensic Examination of Hair*. London: Taylor & Francis. 1999;243–260.