



ORIGINAL RESEARCH PAPER

Health Science

HAIR ANALYSIS AND A COMPARATIVE STUDY OF DIFFERENT RACIAL GROUPS

KEY WORDS: Hair analysis, racial groups, variations, macroscopic features, microscopic features

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ABSTRACT

Hair is an important element or the most common biological evidence found at the scene of crime and plays a crucial role in criminal investigations related to the fields of forensic science. The present study is aimed to a comparative study of macroscopic and microscopic features of hair and to examine the variations reported from the previous studies on hair of different racial groups. Following standard procedure, a total of 150 volunteers head hair samples with their consent, each 50 from Caucasoid, Mongoloid and Negroid have been collected. The hair sample was suitably mounted using a clean microscopic glass slide for analysis under the different magnification viz. 20X, 40X and 100X and recorded with my caps 1080 HD resolution camera. The result of the hair analysis showed marked differences among the three race and variation were reported with the previous studies of hair analysis. The frequency and percentage of distribution of various macroscopic and microscopic features were tabulated and presented in form of bar graphs.

INTRODUCTION

Human hair has a significant role in forensic investigations and considered as class evidence as alone it cannot be used to identify a specific individual. Hair is an important element or the most common biological evidence found at the scene of crime and plays a crucial role in criminal investigations related to the fields of forensic science. Forensic scientists distinguish six types of hair on the human body i.e., head hair, eyebrows and eyelashes, beard and mustache, underarm, auxiliary or body and pubic hair ^[1]. Each hair consists of its own shape, form, texture and morphological characteristics. Forensic scientist carries out mainly three types of hair analysis i.e., chemical assays, DNA analysis and microscopic comparison. Microscopic comparison is used to ascertain if the hair collected is from the same person or not.

In case of violent offences such as murders, assaults, road accidents, rapes, etc., hairs are likely to get detached from the scalp and other areas of the body and get transferred directly or from one person to another or on the clothing during the act of a crime ^[2]. Even thefts of animals may result into shedding of animal hairs on the person or vehicle involved in the offence. In case of assaults and murders, hairs may readily get attached to the instrument used during the offence. An examination of such hair will help in establishing whether the instrument found at the scene of crime used during the offence or not. Sometimes it may be possible to identify a deceased person from hair, as hair is the only post mortem remains recovered ^[2].

A hair found at a scene of crime can be of a particular racial group. With the help of macroscopic and microscopic hair analysis, the racial groups can be differentiated from one another. Caucasoid, Mongoloid and Negroid are the three original ethno hair profiles, each having their own characteristics, which differentiate them from each other. The features of individual hairs, which serve to identify the origin from which they come, are hair color, hair form, hair texture, shaft diameter, pigment granules, pigment distribution, cuticle thickness, medulla pattern, and the cross-sectional shape. Head hairs are generally considered best for determining the race i.e., whether the hair belongs to the Caucasian race, Mongolian race or to the Negroid. These characteristics of hair can be helpful in differentiating the hair of one race from the hair of another race during the forensic investigations. Different races have different macroscopic

and microscopic characteristics that can be of immense help in the criminal justice system. Rate of crime is increasing day by day and it is important to provide justice to the victim. Hair found at a scene of crime is important evidence that can link one person to another and helps in the determination of crime. Hair found can be of a different race. Therefore, to confirm the origin of the hair it is important to examine the characteristics of hair under a microscope. Different racial groups have different hair characteristics and on the basis of the macroscopic and microscopic features of hair the race from which the hair belongs can be determined and the results can help in the identification the suspect or the offender and this is also useful for the criminal justice system.

MATERIALS AND METHODS

A total of 150 volunteers head hair samples, 50 each from Caucasoid, Mongoloid and Negroid population were collected. The age, sex of each individual recorded for reference. Approximately 5-6 hair samples per participant were collected. The samples were extracted from different areas of head using forceps and the collected samples were packed in separate envelopes and labeled. Consent of each subject was obtained (verbally), and they were requested to provide head hair samples.

SELECTION CRITERIA

- Samples of head hair from 150 subjects ranging in age from 20-25 years were selected for the present study.
- The samples were collected from the Chandigarh and Delhi.
- The age, sex, use of color treatments such as dyes, bleaches or lighteners and artificial treatments such as hair spray, hair gel, and cosmetics of each individual was recorded for reference.

SAMPLE PREPARATION

For macroscopic and microscopic examination, the length of hair was placed on a clean glass slide in parallel fashion. Then few drops of transparent such as distilled water or glycerin were dropped on cover slip and it was placed over the slide to fix the hairs. The prepared slides were examined under phase contrast and light microscope with different magnification viz. 40X, 100X and photographed by my caps 1080 HD resolution camera. Hair color, length and texture, cross sectional shape, thickness of cuticle, inner cuticle margin, outer cuticle margin, scale pattern, cortex, natural pigmentation including

pigment aggregation and distribution, medulla and its pattern were observed.

For observing scale pattern, each hair sample was cleaned before examination to remove dust. On a clean microscopic slide, a thin layer of nail polish was brushed onto the middle third of a microscopic slide. With fine forceps, the hair specimen was carefully pressed into the nail polish until it adheres, and allowed to dry for 2-5 minutes. The hair specimen was pulled using the forceps from the slide in one smooth motion. The scale impressions left on the cast was examined and photographed.

For observing cross section mounts of the hair, it was cleaned in ether and ethanol 1:1 ratio mixture. The samples were bundled and dipped in a block of wax and allowed to cool. Cross sections were taken with microtome. The sections were placed on a clean slide and the wax was dissolved by heating and examined under the microscope.

RESULT AND DISCUSSION

After observing all hair samples of different races, following results were obtained:

MACROSCOPIC ANALYSIS

Macroscopic examinations are useful for observing hair characteristics which includes hair color, form, shape and texture. This is an important step in identifying hair of different races. In the present study of Caucasoid, mongoloids and Negroid, it has been observed that brown hair color is more prevalent in the population among the three races. In Caucasoid, out of 50 samples 32 were light and 18 were dark brown hair color. In mongoloids, out of 50 samples 29 were dark brown and 21 were black hair color. In Negroid, out of 50 samples 47 were black hair color. The percentage distributions are shown in figure no. 1. Previously, Mathilda in year 2008 reported dissimilar result among the mongoloids. He stated that black hair color is more prevalent than other hair colors. Jaydip Sen in year 2010 reported dissimilar results among the Caucasoid and mongoloids. He observed that in Caucasoid brown to black hair color is more prevalent. Present study has observed significant variations in the hair color of Caucasoid and mongoloids. In case of Caucasoid higher frequency of light and dark brown hair color have been observed. In mongoloids, the frequency of dark brown hair color was observed to be more than the other hair colors. Previous studies have reported similar results in Negroid and no variations are observed. The comparison of results from the present and previous study is shown in table no. 1.

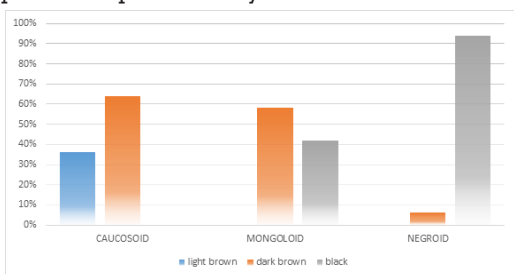


Figure 1. Bar graph showing hair color in Caucasoid, Mongoloid and Negroid

Table 1. Showing variation in the hair color among the races

RACE	PRESENT STUDY RESULTS	PREVIOUS STUDY RESULTS
1. Caucasoid	Brown, black or blonde	Brown to black
2. Mongoloid	Brown or black	Black
3. Negroid	Black or dark brown	Black

The present study of hair form showed variations among the races. In Caucasoid the most prevalent hair form observed is flat wavy. Out of 50 samples 24 samples were flat wavy, 11

samples were broad wavy, 10 samples were straight and only 4 samples were curly. In mongoloids, the frequency of straight hair form is more. 42 samples were straight and only 8 samples were flat wavy. In Negroid, the frequency of frizzly hair form is more. 25 samples were frizzly, 18 sample were spiral and only 7 samples were pepper corn. The percentage distributions are shown in figure no. 2. Alan Olsen in year 1995 and Mathilda in year 2008 reported that the Caucasoid head hair form ranges from straight to kinky and usually wavy. Present study has observed dissimilar results and variation in the hair form of Caucasoid. Higher frequency of wavy hair form has been observed. Previous studies have reported similar results in the hair form of mongoloids and Negroid and no variations are observed. The comparison of results from the present and previous study is shown in table no. 2.

Figure 2. Bar graph showing hair form in Caucasoid, Mongoloid and Negroid

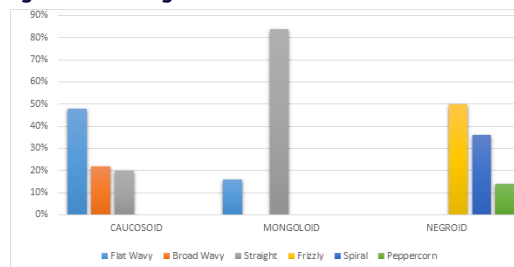


Table 2. Showing variation in the hair form among the races

RACE	PRESENT STUDY RESULTS	PREVIOUS STUDY RESULTS
1. Caucasoid	Straight, flat wavy, broad wavy or narrow wavy	straight to kinky and usually wavy
2. Mongoloid	Straight, flat wavy	Straight
3. Negroid	Frizzly, spiral, pepper corn	Frizzly, spiral, pepper corn

This study includes the observation of hair texture of the three races i.e. Caucasoid, mongoloids and Negroid. In Caucasoid, the hair texture was fine and medium. In mongoloids, the hair texture was coarse. In Negroid the texture was short, curly and finest. Previously Douglas W. Deedrick in year 2000 has reported similar results. Jaydip Sen in year 2010 also reported such individual differences and these differences are still considered valid and significant for determining the race. The comparison of results from the present and previous study is shown in table no. 3.

Table 3. showing variation in the hair Texture among the races

RACE	PRESENT STUDY RESULTS	PREVIOUS STUDY RESULTS
1. Caucasoid	Fine to medium	Fine to medium
2. Mongoloid	Coarse	Coarse
3. Negroid	Coarse	Coarse

MICROSCOPIC ANALYSIS

The microscopic characteristic plays an important role in the forensic comparison of human hair and the microscopic hair structures useful to the forensic hair examiner are cuticle, cortex and medulla.

In the given study it has been observed that thick cuticle is more prevalent in the population among the three races. The result of cuticle thickness in three races showed that the frequency is found to be more in mongoloids. In Caucasoid, out of 50 samples 32 were thick and 18 were thin. In mongoloids, out of 50 samples 40 hair samples were thick and only 10 hair samples were thin. In Negroid, out of 50 samples 29 were thick and only 21 samples were thin. The percentages distributions are shown in figure no. 3. Previously Sen J (2010) and Draelors Z (2016) have reported dissimilar results in case

of Caucasoid. According to them medium cuticle is present in more frequency whereas the present study has observed higher frequency of thick cuticle and showed variations in cuticle thickness of Caucasoid. In case of mongoloids and Negroid, Sen J (2010), M. Chalmers (2012) and Draelors Z (2016) have reported similar results and no variations are observed. The comparison of results from the present and previous study is shown in table no. 4.

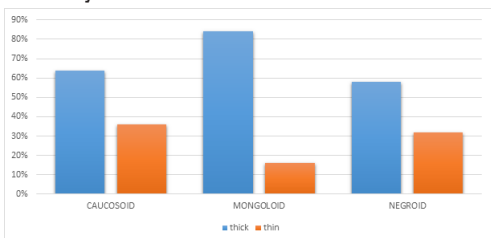


Figure 3. Bar graph showing cuticle thickness among the races

Table 4. Showing variation in the cuticle thickness among the races

RACE	PRESENT STUDY RESULTS	PREVIOUS STUDY RESULTS
1. Caucasoid	Thick or thin cuticle	Thin cuticle
2. Mongoloid	Thick cuticle	Thick cuticle
3. Negroid	Thick or thin cuticle	Medium cuticle

In case of inner cuticle margin of hair it has been observed that distinct inner cuticle margin is more prevalent in the population among the three races. The result of inner cuticle margin in three races showed that the frequency of distinct inner cuticle margins found to be more in Caucasoid. In Caucasoid, out of 50 samples 38 samples were distinct, and 12 were indistinct. In Mongoloid, 42 samples showed distinct inner margin and only 8 samples showed indistinct inner cuticle margin. In Negroid, 31 samples showed distinct inner cuticle margin and only 19 samples showed indistinct inner cuticle margin. The percentage distributions are shown in figure no. 4.

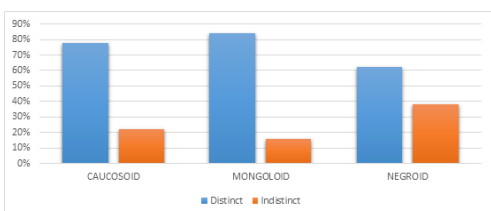


Figure 4. Bar graph showing inner cuticle margin among the races

The study shows the parameter of outer cuticle margin in which it has been observed that smooth outer cuticle margin is more prevalent in the population among the three races. The result of outer cuticle margin in three races showed that the frequency of smooth outer cuticle margins found to be more in mongoloids. In Caucasoid, out of 50 samples, 31 hair samples were smooth, 14 were serrated, and only five were cracked. In mongoloids, 38 hair samples were smooth, 10 were serrated and only 2 samples were cracked. In Negroid, 19 hair samples were smooth, 18 were serrated and 13 samples were cracked. The percentage distributions are shown in figure no.5.

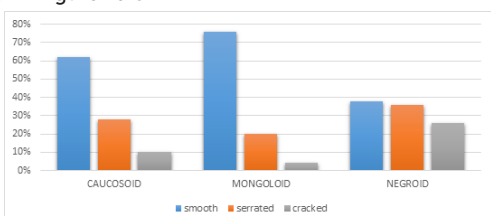


Figure 5. Bar graph showing outer cuticle margin among the races

The observations of scale pattern present in hair sample of three races, Caucasoid, mongoloids and Negroid, it is given that imbricate (flattened) scale pattern is more prevalent in the population among the three races. Previous studies have reported similar results and the Present study showed no variations among the races and all three races showed the same imbricate (flattened) scales. Deedrick W.D and Koch L.S (2004) reported similar results and concluded that human's hair consists of flattened scales. Zainuddin Z, Pannurchelvam S (2009) and Thompson B.R (2012) have also reported similar results. The comparison of results from the present and previous study is shown in table no. 5.

Table 5 showing variation in the scale pattern of hair among the races

RACE	PRESENT STUDY RESULTS	PREVIOUS STUDY RESULTS
1. Caucasoid	Flattened	Flattened
2. Mongoloid	Flattened	Flattened
3. Negroid	Flattened	Flattened

By taking the parameter pigment distribution in hair, it has been observed that the uniform or evenly distributed pigment distribution is more prevalent in the population of Caucasoid and mongoloids, whereas in Negroid it has been observed that uneven pigment distribution is more prevalent. The result showed that in Caucasoid, out of 50 samples 30 hair samples were uniform, 14 were peripheral, and 6 were one sided. In mongoloids, 29 hair samples were uniform, 16 were peripheral and 5 were one sided. In Negroid, 25 hair samples were unevenly distributed, 12 were uniform and 13 were peripheral. The percentage distributions are shown in figure no. 6. Previously Olsen A (1995), Koch S.L (2004), Mathilda (2008), Sen J (2010) M. Chalmers (2012) reported such individual differences in the pigment distribution among the three races. In this study peripheral and one sided distribution has also been observed among the three races along with the evenly and dense pigment distribution. The comparison of results from the present and previous study is shown in table no. 6.

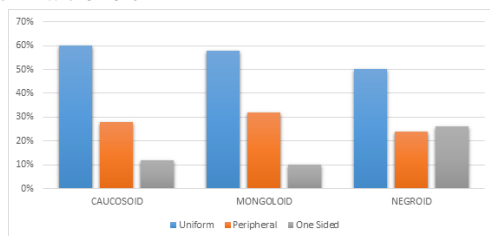


Figure 6. Bar graph showing pigment distribution among the races

Table 6 showing variation in the pigment distribution of hair among the races

RACE	PRESENT STUDY RESULTS	PREVIOUS STUDY RESULTS
1. Caucasoid	Evenly distributed and peripheral	Evenly distributed
2. Mongoloid	Peripheral	Unevenly
3. Negroid	Coarse	Coarse

The pigment aggregation is observed in hair samples of three races. The results showed the presence of moderately dense pigment the cross section of hair in Caucasoid whereas in case of mongoloids the pigment granules are arranged in large patches or streak and in case of Negroid the pigment granules are arranged in clumps. Previously Olsen A (1995), Koch L.S (2004), Mathilda (2008), M. Chalmers (2012) have reported similar results and the present study showed no variations among the three races. The comparison of results from the present and previous study is shown in table no. 7.

Table 7 showing variation in the pigment aggregation of hair among the races

RACE	PRESENT STUDY RESULTS	PREVIOUS STUDY RESULTS
1. Caucasoid	Dense	Dense
2. Mongoloid	Streaky or patchy	Streaky or patchy
3. Negroid	clumped	Clumped

The study of cross sectional shape of hair gave the variable results. The results showed that the cross sectional shape of hair in Caucasoid was oval or slightly round but in the case of mongoloids the shape was round and in the case of Negroid the shape of the hair sections was flattened or elliptical which is the most characteristic feature. Previously Steggerda M (1940), Hicks J.W (1997), Olsen A (1995), Koch L.S (2004), Mathilda (2008), Sen J (2010), M. Chalmers (2012) have reported similar results and the present study showed no variations among the three races. The comparison of results from the present and previous study is shown in table no. 8.

Table 8 showing variation in the cross sectional shape of hair among the races

RACE	PRESENT STUDY RESULTS	PREVIOUS STUDY RESULTS
1. Caucasoid	Oval	Oval
2. Mongoloid	Round	Round
3. Negroid	Flat or elliptical	Flat or elliptical

The present study included the observation of medulla and it has been observed that fragmented medulla is more prevalent in the population of Caucasoid and mongoloids and Negroid. The result showed that in Caucasoid, out of 50 samples 27 hair samples were fragmented, 10 were continuous, 8 were absent and only five were interrupted. In mongoloids, 35 hair samples were fragmented, 3 were continuous, 10 were absent and only 2 samples were interrupted. In Negroid, 36 hair samples were fragmented, 5 were continuous and only 9 samples were absent. The percentage distributions are shown in figure no. 7. Previously Olsen A (1995) have reported the presence of discontinuous medulla in Caucasoid, continuous medulla in mongoloids. M.Chalmers (2012)2012 have also reported similar results. In present study, significant difference was observed among the three races. In case of Caucasoid all the four types of medulla i.e. continuous, fragmented, and interrupted or absent has been observed. In mongoloids Alan Olsen, John M. Chalmers have stated that the medulla is unbroken and this is the most important characteristic feature of mongoloids. Whereas present study has observed a higher frequency of fragmented medulla along with the presence of continuous, interrupted and absent type of medulla. This is the most significant variation that has been observed. In case of Negroid previous studies have reported similar results. The comparison of results from the present and previous study is shown in table no. 9.

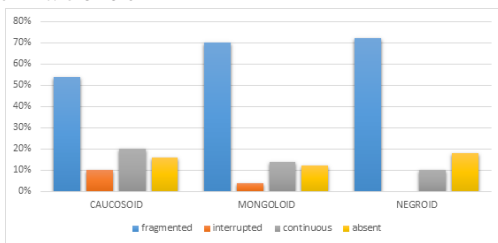


Figure 7. Bar graph showing medulla pattern distribution among the races

Table 9 showing variation in the medulla pattern of hair among the races

RACE	PRESENT STUDY RESULTS	PREVIOUS STUDY RESULTS
1. Caucasoid	Continuous, fragmented, interrupted and absent	Fragmented and absent

2. Mongoloid	Continuous, fragmented, interrupted and absent	unbroken
3. Negroid	Fragmented or absent	Fragmented or absent

CONCLUSION

The present study highlights the different macroscopic and microscopic characteristics of hair among the Caucasoid, Mongoloid and Negroid. The major findings in the cuticle, medulla and pigment distribution among the three races showed the characteristic variations among three races. Therefore these characteristic differences in hair give a unique identity to particular race. With the above findings of the present study it can be concluded that the hair evidence in any form can be used as crucial evidence in real crime scenarios. The present results can be used during criminal investigations and can narrow down the suspects.

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