

Further Studies on The Relationship Between Hair Diameter and Incidence of Medulla

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ABSTRACT The incidence of medulla was determined in 1000 scalp hair strands, from 100 individuals belonging to the Bengalee population in West Bengal. Both the scoring method and the medullary ratio method were used. The relation of the incidence of medulla obtained by the medullary ratio method, and mean hair diameter show a high positive correlation between the two. A regression of incidence of medulla on hair diameter show a positive regression coefficient. The utility of the medullary ratio method over the scoring method for the determination of medulla is discussed.

INTRODUCTION

The hair medulla is composed of keratinised remains of cornified epithelial cells. Using polarised light, medulla is seen to contain air spaces and pigmentation. The incidence of medulla, which is a qualitative character, has been studied with respect to age, race and sex variation (Duggins and Trotter, 1950; Trotter et al., 1956; Banerjee, 1959, 1963a, 1963b; Banerjee and Bhattacharya, 1978; Bhattacharya, 1978 and Das Chaudhuri and Chopra, 1984). Attempts have been made to understand the hereditary basis of the incidence of medulla (Das Chaudhuri, 1976a, b and Das Chaudhuri and Chopra, 1983, 1984).

The relation of hair medulla and diameter was first observed by Osterlone (1874) and subsequently confirmed by Hausman (1924). The absence or presence of medulla is in direct agreement with the diameter of the shaft (Wynkoop, 1929; Hausman, 1930). The relationship between medulla and different hair forms was shown by Banerjee (1956, 1957, 1965) who found frizzly and woolly hair showing the highest incidence of absence of medulla,

with straight hair the highest incidence of presence of medulla. It has also been shown that when medullated and non-medullated hairs of equal length and diameter of an individual are weighed separately, the weight of the former always exceeds that of the latter (Banerjee and Ghose, 1968). From these aspects, the function of medulla may be noted. The medulla acts as a support for the hair strand, making it rigid. It was concluded by Sarkar and Banerjee (1956) that hair diameter appeared to be correlated with medulla types, but no statistical derivations were advanced.

Using the scoring method, Hrdy (1973) obtained a high positive correlation between hair diameter and medulla ($r=0.678$). Later on, using the medullary-ratio method, Das Chaudhuri (1979) confirmed Hrdy's result ($r=0.702$). The above results show that either of these two methods can be used for the estimation of the relationship between hair diameter and medulla. However, most of the studies in this regard, including those mentioned above, were not on Indian populations. Furthermore, no one has used the medullary-ratio and the scoring methods on the same samples to analyse the relationship between hair diameter and medulla. The present study, therefore, aims to determine the hair diameter and incidence of medulla in the Bengalee population, and to find out the relationship between the two. By "Bengalee" population, it is meant the Bengalee Hindu Caste Population (BHCP). The BHCP is a Bengali-speaking endogamous caste group of West Bengal and faithful to Hinduism. It consists of scheduled and non-scheduled caste groups. Ethnically, the BHCP is probably a blend of Dravidian and Mongoloid stocks

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with a strain of Indo-Aryan blood in the higher caste groups (Risley, 1891; Das Chaudhuri et al., 1993). In the present study, both the scoring method of Hrdy (1973) and the medullary-ratio method of Banerjee and Das Chaudhuri (1969) are used to determine the incidence of medulla. The potential advantages of the medullary-ratio method over the scoring method are later summarised.

MATERIAL AND METHOD

The material consists of scalp hair samples from 100 individuals ($N=100$), collected from the nape of the neck (all males, age group : 18-36 years) and residing in Cooch Behar town in West Bengal. The hair samples were washed successively with extran (a non-ionic detergent), sodium lauryl sulfate (an ionic detergent), and dried with acetone, modifying the methods of Harrison et al. (1969), Petering et al. (1973) and Jamall and Jaffer (1987). All the reagents were manufactured by Merck (AR Grade).

A total of 10 strands per individual (sample) were studied for medullation and diameter, thereby, studying 1000 strands. Each strand was cut close to the scalp and the proximal 5 cm were sampled and washed. The diameter was determined at fixed points at the root and tip ends and at the middle of the strand. The entire length of 5 cm was scanned for the incidence of medulla (Fig. 1). A Carl Zeiss-Jena Nr 148910 optical microscope equipped with a

10X ocular along with a micrometer, and with NA of 0.45 was used for the determination of medulla and diameter. The ocular micrometer was calibrated with a stage micrometer (1 division corresponding to 10μ), such that 1 ocular micrometer division corresponded to 5μ . The incidence of medulla was obtained for the same strands using both the scoring method and the medullary-ratio method.

To minimise the technical error, repeated measurements were taken on 10 strands (3 repeated measurements, 3 places on the strand). A difference of 0% - 3% was found during each set of measurements.

RESULTS AND DISCUSSION

Hair medulla has been classified into various categories. Sarkar and Banerjee (1956) divided hair medulla into absent, scanty, broken and continuous. However, due to problems of differentiation between scanty and broken medulla, a medullary-ratio classification into medulla present and medulla absent was put forward by Banerjee and Das Chaudhuri (1969). In this case the medullary-ratio was obtained by dividing the number of strands having medulla by the total number of strands studied. Later on Hrdy (1973) formulated the scoring method, where the numbers 0, 1 and 2 were assigned to the absence of medulla, discontinuous medulla and continuous medulla, respectively.

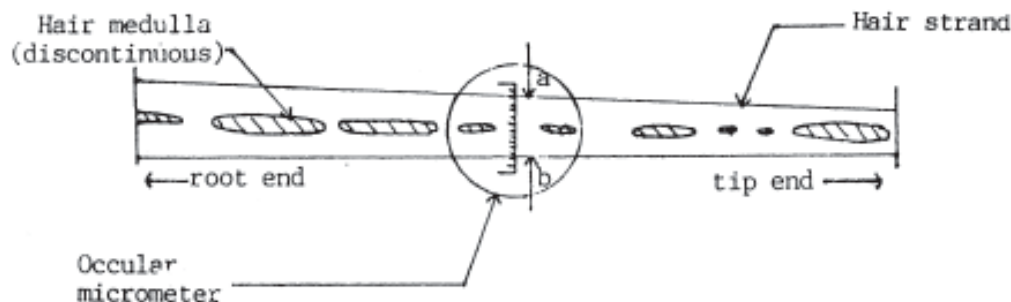


Fig. 1. The measurement of hair diameter (a-b) and determination medulla (not to scale)

Das Chaudhuri and Chopra (1984) have shown the mean and standard deviation of hair diameter and hair medulla among the various Indian populations. Their results along with those found in the present study are given in table 1. The incidence of medulla in all these studies are by the medullary-ratio method. The values in our study are higher than that of the Bengalee population of Das Chaudhuri and Chopra (1984) regarding both hair medulla and diameter. Initially the differences in the results can be attributed to the differences in the sample sizes of the two studies. A lower standard deviation in the present study shows that this population is more homogenous than that of Das Chaudhuri and Chopra (1984). The location of the hair strand can also be an added factor. The present study sampled the proximal 5 cm from the nape of the neck, while in the other study, the samples were from the occipital region and the length was not fixed. Expectedly, with a low standard deviation in both the incidence of medulla and the diameter, the results in the present study have a lower standard error than that of Das Chaudhuri and Chopra (1984) (Medulla : 0.021 vs 0.069; Diameter : 0.955 vs 1.660). A larger sample

Table 1 : Mean $\pm$ standard deviation of medulla and diameter of hair in various Indian populations (after Das Chaudhuri and Chopra, 1984, or as otherwise stated)

Population	N Individual	Males	
		Medulla	Diameter (μ m)
Juang	25	0.70 $\pm$ 0.22	91.21 $\pm$ 9.2
Kadar	38	0.71 $\pm$ 0.19	85.27 $\pm$ 11.22
Munda	25	0.76 $\pm$ 0.19	91.90 $\pm$ 9.2
Onge	11	0.29 $\pm$ 0.18	75.40 $\pm$ 9.91
Oraon	24	0.77 $\pm$ 0.17	95.95 $\pm$ 9.77
Pahira	18	0.56 $\pm$ 0.22	83.81 $\pm$ 13.37
Sabara	25	0.68 $\pm$ 0.17	80.19 $\pm$ 8.55
Santal	24	0.75 $\pm$ 0.23	87.30 $\pm$ 8.45
Bengalee	50	0.61 $\pm$ 0.21	78.03 $\pm$ 9.55
Bengalee*	100	0.74 $\pm$ 0.21	85.38 $\pm$ 9.55

*Present Study

size of the present study also contributes to the lower standard error.

In case of diameter, the within-individual and between-individual variance is shown in table 2, along with those obtained by Das Chaudhuri and Chopra (1984). Highly significant F-values for all the populations including ours are seen. This indicates that for diameter, individuals differences exist. It also shows that the mean of the different observations on an individual is justified as being representative.

Table 2 : Within and between-individual F ratios for hair diameter (after Das Chaudhuri and Chopra 1984, or as otherwise stated)

Population	Male		
	Within-individual variance	Between-individual variance	F ratio
Juang	13.3175	132.558	9.954
Kadar	9.5303	196.7107	20.641
Munda	11.8483	79.3872	6.700
Onge	6.2797	153.6697	24.471
Oraon	13.785	89.5225	6.494
Pahira	9.0623	279.5347	30.846
Sabara	11.8578	122.6422	10.343
Santal	12.0433	79.4986	6.600
Bengalee*	10.5785	111.9714	10.585

*Present study

The complete analysis of variance in the present study takes the following form :

Source of variation	s.o.s.	df.	Mean square
Between samples	11085.17	99	111.9714
Within samples	30677.57	2900	10.5785
Total	41762.74	2999	13.9256

The correlation between hair diameter and hair medulla, and the regression for hair medulla on diameter were estimated. The incidence of medulla was estimated using both the medullary-ratio method and the scoring method. The results are given below in table 3. Identical values were obtained using both the methods.

Table 3 : Correlation and regression values in the present study (N=100)

	<i>r</i>	<i>t</i> -value	<i>a</i>	<i>b</i>	<i>t</i> -value
Correlation	0.6745	9.045* (df:98)	—	—	—
Regression	—	—	-0.529	0.015	25.42* (df:98)

*Significant at 1% level.

The correlation coefficient '*r*' is in agreement with those of Hrdy (1973) and Das Chaudhuri (1979). The value is significant, in conformity with the earlier contentions that the presence of medulla increases with an increase in hair diameter. The regression coefficient '*b*' is also significant, thereby showing the dependence between the two parameters. The regression of incidence of medulla on diameter is shown in figure 2.

As mentioned earlier, the scoring method envisages the assignment of the arbitrary number 0 for no medullation (medulla absent), 1

for discontinuous medullation (medulla present) and 2 for continuous medullation (medulla present). The numbers are assigned for the each hair strand and added up for every individual. In the medullary-ratio method, the number of hair strands having the presence of medulla is divided by the number of hair strand studied to obtain the ratio for each individual. The scoring method therefore takes into account hair strands with both continuous medulla and discontinuous medulla.

In the present study, no hair strands have been found with continuous medullation. Furthermore, all the individuals had a mixture of medullated (discontinuous medulla) and non-medullated (absent) hair. So the values assigned to each individual on the basis of the scoring and the medullary-ratio method were the same. But here is a catch. If it is assumed that out of 10 strands of an individual, 2 have continuous medullation and 8 discontinuous medullation, then the medullary-ratio method

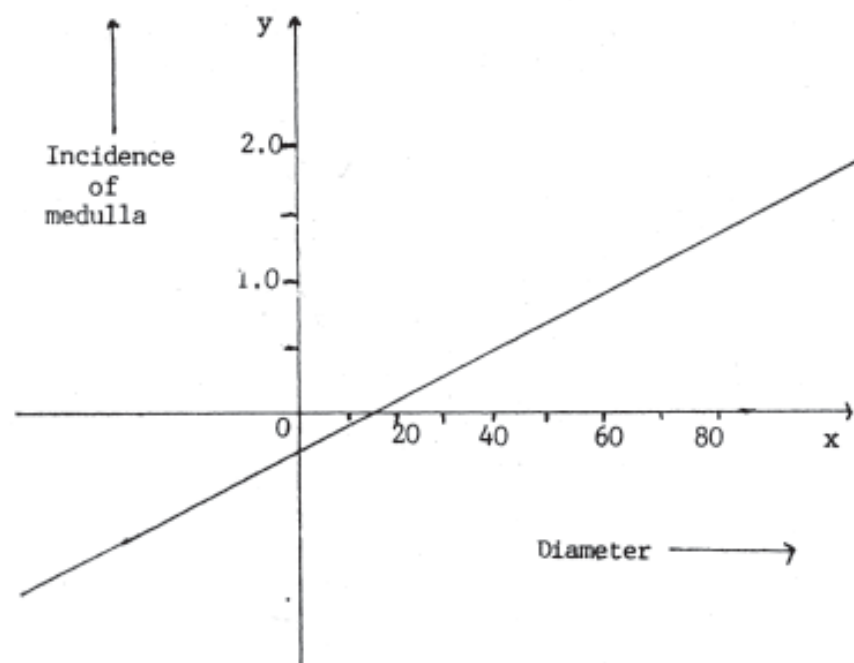


Fig. 2. The regression of incidence of medulla on hair diameter

assigns the incidence of medulla as 1 (10 strands with medulla/total 10 strands studied = 1). A value of 12 is obtained using the scoring method, 1 each for 8 strands with discontinuous medulla and 2 each for 2 strands with continuous medulla. Again, if all the strands have discontinuous medulla, the medullary-ratio still assigns to value 1, but the scoring method assigns the value 10, not 12 as in the previous case. These small differences lead to differences in the statistical derivations. The mode of distinguishing between continuous and discontinuous medulla types is an added factor. These issues tend to throw light on the fact that use of the medullary-ratio method is advantageous over the scoring method.

It may be, therefore, concluded that the mean hair diameter, and incidence of medulla obtained in the present study, though elevated, are in conformity, compared to those in Bengalee population of the Das Chaudhuri and Chopra (1984). Facts such as the nature of the samples and the homogeneity of the populations are responsible for this. The correlations and regression values are in agreement with other similar studies. The medullary-ratio method tends to be useful than the scoring method.

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REFERENCES

- Banerjee, A.R. : Hair character of the Juang and other tribes of Orissa. *Man in India*, **36** : 195-198 (1956).
- Banerjee, A.R. : Further histological studies on Negrito hair : The Onge of the Andaman Islands. *Man in India*, **37** : 249-256 (1957).
- Banerjee, A.R. : Kadar hair. pp. 37-49. In : *Physical Survey of the Kadar of Kerala*. Mem. No. 6, Dept. of Anthropology, Govt. of India (1959).
- Banerjee, A.R. : Variation in the medullary structure of human head hair. *Proc. Nat. Inst. Sci. India*, **29B** : 306-316 (1963a).
- Banerjee, A.R. : A study of the head hair characters of the aborigines of Western Australia. *Oceania*, **34** : 60-65 (1963b).
- Banerjee, A.R. : On variation of human head Hair : Hair form and medullation. *Z. Morph. Anthropol.*, **57** : 56-69 (1965).
- Banerjee, A.R. and Bhattacharjee, B. : Sex difference in histological characteristics of human hair. *Ind. J. Forensic Sci.*, **17** : 45-54 (1978).
- Banerjee, A.R. and Das Chaudhuri, A.B. : Genetics of medullary structure of human head hair. *Man in India*, **49** : 30-40 (1969).
- Banerjee, A.R. and Ghosh, S. : *Studies on Hair Weight*. Dissertation, University of Calcutta, Calcutta (1968).
- Bhattacharya, B. : *On Quantitative Variation of Human Hair with Special Reference to Personal Identification*. Ph. D. dissertation, Unpublished, University of Calcutta, Calcutta (1978).
- Das Chaudhuri, A.B. : Genetic basis of hair medulla by twin study. *Am. J. Phys. Anthropol.*, **44** : 51-54 (1976a).
- Das Chaudhuri, A.B. : A twin study of the structure of human hair medulla. *Hum. Hered.*, **26** : 167-170 (1976b).
- Das Chaudhuri, A.B. : Human scalp hair genetics by twin study. In : *Progress in Clinical and Biological Research*. W.E. Nance (Ed.). Alan R. Liss. New York (1978).
- Das Chaudhuri, A.B. : *A Study on Genetics of Quantitative Variation of Human Head Hair*. D.Sc. Thesis, Unpublished, University of Calcutta, Calcutta (1979).
- Das Chaudhuri, A.B. and Chopra, V. : Genetic basis of hair histomorphological variable. *Am. J. Phys. Anthropol.*, **60** : 1-6 (1983).
- Das Chaudhuri, A.B. and Chopra, V. : Variation in hair histological variable : Medulla and diameter. *Hum. Hered.*, **34** : 217-221 (1984).
- Das Chaudhuri, A.B., Basu, S. and Chakraborty, S. : Twinning rate in the Muslim population of West Bengal. *Acta Genet. Med. Gemellol.*, **42** : 35-39 (1993).
- Duggins, O.H. and Trotter, M. : Age changes in head hair from birth to maturity. II. Medullation in hair of children. *Am. J. Phys. Anthropol.*, **8** : 399-415 (1950).
- Harrison, W.W., Yurachek, J.P. and Benson, C.A. : The determination of trace elements in human hair by atomic absorption spectroscopy. *Clin. Chim. Acta*, **23** : 83-91 (1969).
- Hausman, L.A. : Further studies on the relationship of the structural characters of mammalian hair. *Am. Nat.*, **58** : 544-547 (1924).
- Hausman, L.A. : Recent studies on hair structure relationships. *Scien. Month.* **30** : 1930, cited from Duggins O.H. and Trotter M. (1950).
- Hrdy, D. : Quantitative hair form variation in seven populations. *Am. J. Phys. Anthropol.*, **39** : 7-18 (1973).
- Jamal, L.S. and Jaffer, R.A. : Elevated iron levels in hair from steel mill workers in Karachi, Pakistan. *Bull. Environ. Contam. Toxicol.*, **39** : 608-614 (1987).

- Osterlenc, O.: *Das Menschliche haar und seine gerichtsartsliche bedeutung*. Tübingen (1874).
- Petering, H.G., Yeager, D.W. and Witherup, S.O. : Trace metal content of hair : II. Cadmium and lead of human hair in relation to age and sex. *Arch. Environ. Health*, 27 : 327-330 (1973).
- Risley, H.H. : *The Tribes and Castes of Bengal*. Vol. 1, Govt. of India, Calcutta (1891).
- Sarkar, S.S. and Banerjee, A.R. : Histological differences between Negrito and Oraon hair. *Man in India*, 36: 288-291 (1956).
- Trotter, M., Duggins, O. H. and Setzler, F.M. : Hair of Australian Aborigines (Arnhem land). *Am. J. Phys. Anthropol.*, 14 : 649-659 (1956).
- Wynkoop, E.M. : A study of the age correlations of the cuticular scales, medullas and shaft diameter of human head hair. *Am. J. Phys. Anthropol.*, 13: 177-188 (1929).