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Tensile study of human scalp hair in diffuse Alopecia in females

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Results of the study on the tensile properties of normal healthy scalp hair (500 strands) which were extracted from the occipital region of 50 Bengali-speaking Hindu individuals classified by both sexes and age (0—49 years) were reported earlier by Gupta *et al.* (1979). Similar studies with Japanese samples were conducted by Endo (1933) and Yoshida *et al.* (1959).

In this paper we present the results of a study undertaken to compare the tensile properties of human scalp hair of female subjects with diffuse alopecia against those of normal subjects with no alopecia. Further, attempt has been made to examine if diffuse alopecia has any effect on the tensile properties of scalp hair.

Diffuse alopecia refers to loss of scalp hair without inflammation and scarring Guy *et al.* (1960). This is an enigma and too often creates cosmetic problems associated with mental depression, especially in young adults. Till-to-date, there is no proved therapy available for diffuse alopecia.

Materials and Method

In order to avoid variations in tensile properties due to age, sex and race, the study has been restricted to a small group of Bengali-speaking Hindu adult females aged 20—30 years. Twenty two female subjects—ten with normal hair and twelve suffering from diffuse alopecia—have participated in the study. However, the subjects with diffuse alopecia have been otherwise physically healthy without any obvious pathological signs in scalp skin save gradual thinning of hairs. The mean age of the (I) normal and (II) a-normal categories of females are 23.90$\pm$ 2.28 and 25.25 $\pm$ 3.05 years respectively. The test materials are extracted hair strands from

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the occipital region of all the subjects, 10 from each ; the number of hair specimens available for study are thus 220. The selected strands are all microscopically intact. They are made grease-free by treatment with soap solution and dried in air.

The testing machine used in the study is a single-thread KMI Tensile Tester, Model 1.1 E. It is a power-driven machine of wall-mounting type operating on constant rate of traverse principle the bottom grip being counter-balanced for an easy return to the starting position with a slight push. Its capacity is 0—1 kgf with an accuracy of $\pm$ 1 per cent. Other specifications are : (i) traverse speed = 30 cm/min., (ii) specimen length = adjustable between 5—60 cms , (iii) least count of the elongation scale = 0.1 cm., (iv) power supply = single phase, 230 volts, 50 cycles A. C. The instrument is provided with an automatic load-elongation recorder

The cross-sectional area of each hair strand is calculated by measuring the diameter of the hair shaft with an ocular microscope (8 × 10) fitted with a micrometer scale, 1 division of which represents 14.89 μ. For hairs with elliptic cross-sections, the average of the major and minor axes is taken as the effective diameter.

The specimens 10—15 cm. long are placed lengthwise, one after the other, into the two vertical grips of the machine, the original length of the specimen being the distance between the grips. By an electric motor the specimen is stretched at a constant rate of 30 cm/min. continuously until it breaks. The elongation at break is noted from the final positions of the grips and the corresponding load is observed from the load-recorder.

Results

The tensile properties selected for the comparative study are the ultimate tensile strength (UTS) and the ultimate percentage elongation (UPE). These are defined as under.

UTS = The stretching load required to break the specimen/the cross-section of the specimen.

UPE = the elongation of the specimen at break x 100/the original length of the specimen.

The observational data are presented in Tabel 1

Statistical Analysis

UTS data : For the subjects of category I, we have $n_1 = 10$ and $\sum(x_1 - \bar{x}_1)^2 = 69.81$. Similarly, for the subjects of category II, we have $n_2 = 12$ and $\sum(x_2 - \bar{x}_2)^2 = 36.32$.

So, $$s^2 = \frac{(x_1 - \bar{x}_1)^2 + (x_2 - \bar{x}_2)^2}{n_1 + n_2 - 2} = \frac{69.81 + 36.32}{10 + 12 - 2} = 5.30$$

Thus, $$s = 2.30$$

We proceed with the hypothesis that diffuse alopecia does not exercise any effect on UTS-values. Now,

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s}\sqrt{\frac{n_1 n_2}{n_1+n_2}} = \frac{16.83 - 12.97}{2.30}\sqrt{\frac{120}{22}} = 3.91$$

The table value of t for 20 degrees of freedom at 1% level of significance is 2.84. Hence the calculated value happens to be much greater than the table value. Our hypothesis is thus not true and there is no reason to accept it. We conclude, therefore, that diffuse alopecia does exert a significant effect on the ultimate tensile strength of scalp hair (occipital).

UPE data : Here, we have

$$s^2 = \frac{\sum(x_1-\bar{x}_1)^2 + \sum(x_2-\bar{x}_2)^2}{n_1 + n_2 - 2} = \frac{109.49 + 169.98}{10 + 12 - 2} = 18.97$$

So: $s = 4.35$

We proceed again with the second hypothesis that diffuse alopecia does not exercise any effect on the ultimate percentage elongation and calculated the t value.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s}\sqrt{\frac{n_1 n_2}{n_1+n_2}} = \frac{40.19 - 34.40}{4.35}\sqrt{\frac{120}{22}} = 3.10$$

Since the calculated va ue of t with 20 degrees of feedom is again greater than the table value at 1% level of significance, we conclude that diffuse alopecia does also exert a significant effect on the ultimate precentage elongation.

Discussion

It appears from the foregoing results that the clinical diagnostics of diffuse alopecia has a significant influence on the tensile properties of human scalp hair. It is observed distinctly that the mean value of the strength of normal healthy hair in the given age group is 16.83 ± 2.78 kg/mm^2, whereas the same for hair with manifest alopecia is much lower: 12.97 ± 1.73 kg/mm^2. Similarly, the category with normal hair shows a significantaly higher ultimate percentage elongation : 40.19 ± 3.48% compared to the category exhibiting diffuse alopecia : 34.40 ± 1.76%. Statistical test confirms that the variations in both the tensile parameters are highly significant ($p < 0.01$).

Now, by the law of physics, the product UTS × UPE has a direct bearing on the work done to break the hair specimen. This is a measure of the energy absorption of the specimen concerned. The energy absorbed in normal healthy hair thus explains for a higher quantum than that absorbed in hair in diffuse alopecia. It indicates that alopecia has a role to

introduce mechanical weakness to hair tissues resulting in premature thinning Maddin (1975).

The present study of tensile properties of scalp hair in diffuse alopecia is explorative in nature with a rather limited number of specimens of 22 Bengalee female individuals. Nevertheless, the role of diffuse alopecia to significantly influence the tensile properties of human head hair (occipital—based) has been evident from the study.

Summary

The tensile properties —ultimate tensile strength and ultimate precentage elongation— of normal healthy scalp hair have been compared with those of hair in diffuse alopecia in a study with 22 Bengali speaking Hindu adult female subjects in the age group 20—30 years— 10 having normal hair and 12 suffering from alopecia. The 'normal' category shows a much higher value both in regard to the ultimate strength and percentage elongation compared to the 'diseased' group and the difference is statistically highly significant ($P < 0.01$). It is evident, therefore, that alopecia :

(i) reduces the tensile strength of head hair perdurably;

(ii) reduces also the percentage elongation of scalp hair making it more brittle in nature; further,

(iii) in consequence of (i) and (ii) above, the energy absorbed in hair specimens of subjects with alopecia explain for a much less quantum—a fact indicative of mechanical weakness in hair tissues causing in a premature falling and consequent thinning of scalp hair (occipital).

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Table 1 : Ultimate tensile strength and percentage elongation of human scalp hair (occipital)

Serial No.	Subject initial	Age (Year)	Mean age (Year)	UTS (kg/mm^2)	Mean UTS	UPE (%)	Mean UPE
CATEGORY I : (with normal hair)							
1	PP	21		23.02		39.37	
2	TS	21		14.10		39.17	
3	MP	22		14.86		35.67	
4	MS	23		16.73		42.50	
5	MB	23	23.90±2.28	17.44	16.83±2.78	40.26	40.19±3.48
6	SB	25		15.29		37.31	
7	DL	25		15.80		38.01	
8	SL	25		17.31		42.16	
9	AS	26		19.73		45.60	
10	RS	28		14.05		43.90	
CATEGORY II : (with diffuse alopecia)							
1	SuD	20		12.77		39.65	
2	AC	22		12.47		29.49	
3	JC	22		14.97		34.49	
4	MB	24		12.20		31.77	
5	UR	24		11.71		34.99	
6	AR	25	25.25 ±3.05	14.08	12.97 ±1.73	31.90	34.40 ±3.76
7	MiB	25		13.51		42.77	
8	LS	26		14.66		36.57	
9	GB	26		9.29		34.99	
10	SD	29		11.06		29.11	
11	KP	30		15 87		33.98	
12	SS	30		13.04		33.14	

Statistical t—test	Category Mean	UTS I 16.83	UTS II 12.97	UPE I 40.19	UPE II 34.40
		P<0.01		P<0.01	

References

Endo, N.
1953 Study on the strength of human hair and the mammal hair. *J. Kyto Pref. Med. Univ.*, 53 : 373—389.

Gupta, A. B., Ghosh, K. G. and Haldar, B.
1979 Study on the tensile properties of human scalp hair. *Indian Journal of Dermatology*, 24, 1 : 1—8.

Guy, W. B and Edmundson, W. F.
1960 Diffuse cyclic hair loss in women. *Arch. Dermatol.*, 81 : 205—207.

Maddin, Stuart (ed.)
1975 *Current Dermatologic Management*. Second edition, The C. V. Mosby Co,. Saint Louis, USA.

Yoshida, T.,Bessho, I. and Okamoto, S.
1959 Supplemental report on the strength of human hair. *Med. J. Mutul Aid. Ass*, 8 : 488—493.