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## Microscopic Hair Changes Associated with Hair Coloring, Hair Waving and Hair Ironing in Iranian Women

<sup>1</sup>Shahla Talghini and <sup>2</sup>Mohammadreza Ranjkesh

<sup>1</sup>Department of Pathology, Tabriz University of Medical Sciences, Sina Hospital, Tabriz, Iran

<sup>2</sup>Department of Dermatology, Tabriz University of Medical Sciences, Sina Hospital, Tabriz, Iran

**Abstract:** Although, of no vital value, hair plays a significant role in expressing any person's psychosocial status. Many cosmetic and styling methods are available for hair. This study aimed to examine the microscopic changes in women with hair coloring, hair waving, or hair ironing in comparison with normal controls. In a cross-sectional study, 154 Iranian women were recruited and categorized in 4 groups: controls (n = 35) who had not dyed, waved or ironed their hair within the last 6 months; dyed-hair group (n = 49) who had dyed their hair using standard chemical hair colors at least three times within the last 6 months; waved-hair group (n = 35) who had frizzled their hair within the last 6 months and ironed-hair group (n = 35) who had ironed their hair at least 3 times a week using a temperature more than 30°C within the last 6 months. Hair samples of all four groups were examined microscopically, and the results were compared with the controls. The rate of abnormal findings was 17.1% in the controls, 53.1% in the dyed-hair group, 45.7% in the waved-hair group, and 54.3% in the ironed-hair group. Abnormal findings were significantly more frequent in the last three groups comparing with the controls (p<0.05). Trichorrhexis was 17.1, 34.7, 40 and 11.4%; kinking was 0, 2, 2.9 and 25.7%; pseudo pili-annulati was 0, 6.1, 0 and 17.1%; trichonodosis was 0, 6.1, 0 and 0%; tracheoschisis was 0, 2, 2.9 and 0% and trichoptilosis was 0, 2, 0 and 0% in the mentioned groups, respectively. Based on the results of the present study, hair coloring, waving and ironing all can induce abnormalities in the hair in comparison with the hairs of nonusers.

**Key words:** Hair coloring, hair waving, hair ironing, hair abnormality

### INTRODUCTION

In both genders, hair plays a pivotal role in self perception and can have an immense effect on the psychosocial status of a person. Modern life has enabled human to change and enhance its appearance and the hair is not an exception in this regard. Hair coloring, waving and straightening are among the most frequent manipulations of hair, however, there are scant data regarding their untoward influences on the health (Harrison and Sinclair, 2003; Bolduc and Shapiro, 2001).

There are diverse products and techniques in hair coloring. It can be achieved through gradual, temporary, semi-permanent, or permanent processes. Although, natural compounds (such as henna and chamomile) may be used in this regard, most consumers prefer synthetic dyes, because of their wide range and predictable outcome (Johnson, 1997). Although, many standard products are safe, there is still concern regarding the safety of hair dyes (Cook *et al.*, 1999; Ziadat, 2010).

Waving is a complex process, which generally changes the original bonds which keep the hair in its original position and shape. Various types of perms are available, such as permanent waving solutions (Gray, 2004).

Hair straightening is done by two methods: mechanical and chemical (relaxers). Hot comb and ironing are among the mechanical methods. The heat of a hot comb can reach 300-500°F. Chemical relaxing (lanthionization) is the method of choice in hair straightening this method is somewhat similar to permanent waving, exactly in the opposite direction (Grimes and Davis, 1991).

The objective of the present work is to examine the microscopic changes of the hair in the women using one of hair coloring, waving, or ironing. These changes are compared with a control group who used none of these methods in recent months.

### MATERIALS AND METHODS

In this cross-sectional study, 158 females were randomly selected from different hairdressing salons in Tabriz from May 2012 to February 2013. These women were categorized in four groups:

- **Controls:** who had not dyed, waved or ironed their hair within the last 6 months

- **Dyed-hair group:** who had dyed their hair using standard chemical hair colors at least three times within the last 6 months
- **Waved-hair group:** who had frizzled their hair within the last 6 months
- **Ironed-hair group:** who had ironed their hair at least 3 times a week using a temperature more than 30°C within the last 6 months

Subjects with more than one hairdressing procedure at a time ( $n = 2$ ) and those with abnormal hair (with disease or congenital conditions, ( $n = 1$ )) were excluded. During the study period, another subject refused to continue the study, leaving a total of 154 subjects for the final survey: 35 females in the control group, 49 females in the dyed-hair group, 35 females in the waved-hair group, and 35 females in the ironed-hair group.

This study was approved by the ethics committee of Tabriz University of Medical Sciences and informed written consents were obtained from the participants before enrollment.

Fifteen hair filaments were cut off from the vertex in all participants and the samples were microscopically (light microscope, Siemens, Munich, Germany; with X40 and X100 magnifications) examined by a skilled dermatopathologist in Tabriz Imam Reza Teaching Hospital, Department of Pathology. The dermatopathologist was not aware of the groupings of the participants. The microscopic results were reported in 7 groups (Goldsmith *et al.*, 2012; James *et al.*, 2011):

- **Normal:** No pathological change
- **Trichorrhexis:** Hair break
- **Kinking:** Kinks and twists with or without longitudinal grooving
- **Pseudo pili-annulati:** Alternating optical white and dark bands in the hair shaft
- **Trichonodosis:** Spontaneous knotting of the hair
- **Tracheoschisis:** A clean, transverse fracture through the hair shaft cuticle and cortex
- **Trichoptilosis:** Longitudinal splitting/fraying of the distal end of the hair shafts

Frequency of the microscopic hair examination was compared between the controls vs. each pathologic group.

**Statistical analysis:** Data were shown as mean  $\pm$  standard deviation or number (%). The SPSS software for Windows (ver.16) was used. One-way ANOVA (for age), and the Chi-square test (for the frequency of abnormal findings) were employed for analyzing. The  $p = 0.05$  was considered statistically significant.

## RESULTS

One hundred fifty four participant with a mean age of  $38.4 \pm 8.9$  (range: 20-75) years were enrolled. Percentage of the results of microscopic hair examinations among all these participants are shown in Fig. 1. According to this pie graph, normal hair was the most frequent finding

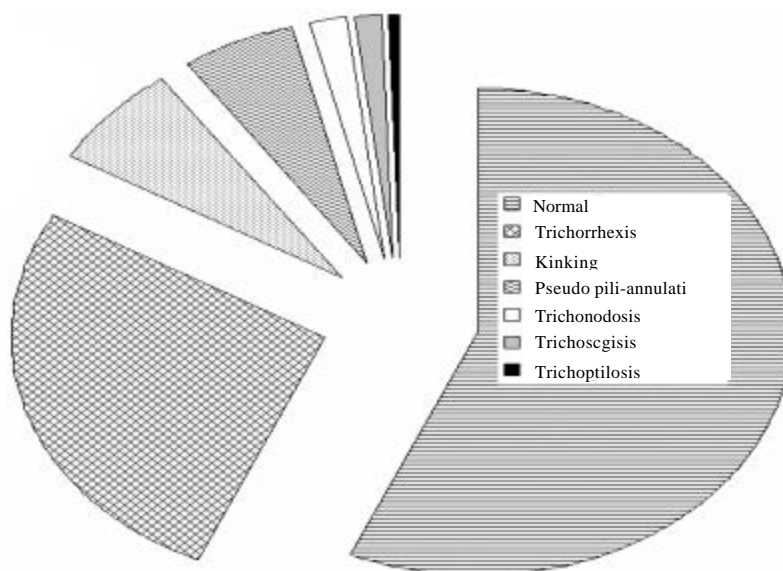


Fig. 1: Overall results of the microscopic hair examinations among 154 studied participants

Table 1: Frequency and percentage of normal and abnormal findings of the hair microscopic examinations in the four studied groups

Group	Microscopic finding		p-value*	Odds ratio	95% Confidence Interval
	Normal	Abnormal			
Controls	29 (82.9)	6 (17.1)	-	-	-
Dyed-hair	23 (46.9)	26 (53.1)	0.001	5.5	1.9-15.5
Waved-hair	19 (54.3)	16 (45.7)	0.010	4.1	1.4-12.3
Ironed-hair	16 (45.7)	19 (54.3)	0.001	5.7	1.9-17.3

Data are shown as frequency (%), p-value = 0.05 is significant, \*Controls vs. Other groups

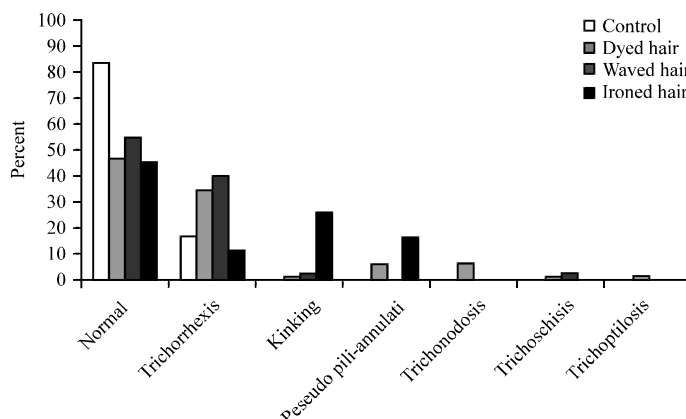


Fig. 2: Percentage of normal and various subgroups of abnormal findings in four studied groups

(n = 87, 56.5%), followed by trichorrhexis (n = 41, 26.6%), kinking (n = 11, 7.1%), pseudo pili-annulati (n = 9, 5.8%), trichonodosis (n = 3, 1.9%), tracheoschises (n = 2, 1.3%) and finally trichoptilosis (n = 1, 0.6%).

The mean age of the subjects was  $38.3 \pm 9.7$  (range: 29-68) years in the control group,  $39.4 \pm 9.6$  (range: 20-75) years in the dyed-hair group,  $38.1 \pm 6.6$  (range: 30-51) years in the waved-hair group and  $37.1 \pm 8.1$  (range: 30-75) years in the ironed-hair group. All the four groups were comparable in terms of their participants' age ( $p = 0.37$ ).

Normal and abnormal microscopic findings in the four studied groups are summarized and compared in Table 1. Accordingly, while the rate of abnormal findings was 17.1% in the controls, it was 53.1% in the dyed-hair group, 45.7% in the waved-hair group and 54.3% in the ironed-hair group. The percentage of abnormal findings was significantly higher in the last three groups in comparison with that in the controls ( $p = 0.001$ ,  $0.010$  and  $0.001$ , respectively).

Percentage of normal, as well as various subgroups of abnormal microscopic findings in different studied groups is shown in Fig. 2.

Accordingly, trichorrhexis was detected in 6 subjects (17.1%) of the control group, 17 subjects (34.7%) of the dyed-hair group, 14 subjects (40%) of the waved-hair group and 4 subjects (11.4%) of the ironed-hair group.

Kinking was reported in 1 subject (2%) of the dyed-hair group, 1 subject (2.9%) of the waved-hair group and 9 subjects (25.7%) of the ironed-hair group.

Pseudo pili-annulati was shown in 3 subjects (6.1%) of the dyed-hair group and 6 subjects (17.1%) of the ironed-hair group.

Trichonodosis was only recognized in 3 subjects (6.1%) of the dyed-hair group.

Tracheoschises was reported in 1 subject (2%) of the dyed-hair group, and 1 subject (2.9%) of the waved-hair group.

Trichoptilosis was only recognized in 1 subject (2%) of the dyed-hair group.

## DISCUSSION

Hair cosmetics and styling constitutes a very important share of the current modern life, because unlike in the past, it is not restricted to females anymore. This widespread use, however, may cause reversible or irreversible damages to the hair which need to be evaluated thoroughly.

For the first time in a sample of Iranian women, this study examined the microscopic changes of the hair after hair coloring, heat-styling and curling in comparison with a well-matched group of controls. Based on the finding, the rate of abnormal hairs was significantly higher in the group used these three types of hair styling vs. the

controls (53.1% in the dyed-hair group, 45.7% in the waved-hair group, and 54.3% in the ironed-hair group vs. 17.1% in the controls,  $p < 0.05$  for all). Apparently, there is no similar report in the literature regarding the types and frequency of damage after these types of hair styling and so, this report is the first one in its type ever.

Draeos (1991) believed that because in using hair cosmetics changes in normal hair structure is inevitable, abnormality always can be seen. In hair styling, disruption of the overlapping cuticular scales induces external damage to the shaft, leaving it vulnerable to static electricity and susceptible to humidity. Furthermore, these products may also cause internal damage to the hair by decreasing shaft's elasticity and hence, enhancing hair breakage.

These findings also confirm these changes. For example, trichorrhexis or hair break was the most common abnormality in all three groups underwent hair styling.

Pande *et al.* (2001) showed that hair dyes make the hair weakened through the oxidative damages induced by the chemical constituents in hair coloring materials.

In the present study, the dyed-hair group suffered from wider range of abnormalities comparing with the other two group, including trichorrhexis, kinking, pseudo pili-annulati, trichonodosis, tracheoschises and trichoptilosis. This may be justified by the difference between hair coloring and waving/hair straightening. This difference is obvious: chemical vs. mechanical affects. As Pande *et al.* (2001) noticed, this chemical effect is probably due to oxidative consequences.

Kizawa *et al.* (2005) enlightened another aspect of hair damage following coloring. They showed that hair treatment chemicals before hair coloring (such as bleaching) may cause severe hair damage. In this study the hair which was bleached was prone to fragmentation of its cuticles into small peptides, which in turn make the hair fragile.

This mechanism may give grounds for the occurrence of trichoptilosis and tracheoschises in these patients who had dyed their hair by chemical colorings. It should be reminded that tracheoschises was seen only in the dyed-hair group.

Harrison and Sinclair (2003), on the other hand, proposed that hair dyes may cause melanin oxidation in the hair cortex. This oxidation further annihilates disulfide bands connected with keratin, and finally deterioration of hair cuticle.

This mechanism further explains the underlying physiopathology of the hair abnormality seen in the dyed-hair group in the current study. This is also confirmed in a study by Ahn and Lee (2002).

Han *et al.* (2008) shown that in hair waving, both mechanical and chemical damage may be expected. The chemical damage is due to waving lotions being used before mechanical waving of the hair. Based on this report, both mechanical and chemical processes decrease the protein content of the affected hair, which in turn, leave the hairs weakened and fragile.

This mechanism justifies the high rate of trichorrhexis in our participants in the waved-hair group. It is worth to note that there were only two other cases in this group with abnormality other than trichorrhexis in this group; a case with kinking, which is apparently due to mechanical change of the hair after waving and a case with tracheoschises, which may be justified again by the protein content-depletion theory by Han *et al.* (2008). Overall, it seems that waving, in comparison with hair coloring and heat styling, causes less frequent damages to the hair. However, due to lack of data in this regard in the literature, further studies merit to be carried out to elucidate the issue clearly.

In a series by Lee *et al.* (2011), it was shown that the hair cortex is resistant toward heat damage. This type of insult may decrease the hair moisture, leading to cell membrane complex damage. The final outcome is hair color change, especially into lightness.

This report completely explains the high rate of pseudo pili-annulati, which is alternating optical white and dark bands in the hair shaft, among the participants who underwent ironing (17.1%).

Zhou *et al.* (2011) concluded that due to very high temperature of hot flat irons (over 200°C), hair keratin damage is pervasive after their use. The final consequence of this damage was easily breakable hair.

The finding of this report justifies our findings regarding no cases of tracheoschises and trichoptilosis in our series in the group of ironed-hair. Indeed, as Zhou *et al.* (2011) emphasized, ironing exposes the hairs to breakage, which is only apparent, for example, after combing. In this study, the hair samples were cut off by the researcher. So, it could be recommended that the hair fibers which drop after combing be used for investigation, as well in future studies.

As mentioned before, this study is the first one which reports the frequency of microscopic hair damage after hair dying, waving and straightening in a group of Iranian women. Based on these finding, all three methods may cause pathological changes in the hair. According to previous reports, other systemic consequences may be expected after these hair styling techniques, such as cardiac complications or even malignancy (Murata *et al.*, 2006; Singh *et al.*, 2009; Jeong *et al.*, 2010).

So, the results of this report should be available to the public in a simplified format, as a precaution for individuals who are inveterate patrons of hairdressing salons.

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