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Effect of Hair Straightening Treatment on Porosity and Cysteic Acid Content of Hair

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Chemical straightening has increased in popularity because of its durability over thermal straightening and because it gives the hair a natural smooth, shiny look, more styling options for a longer time. The aim of this study was to evaluate the degree of damage that occur to the hair after chemical straightener treatment by assessing the change in hair porosity and hair cysteic acid content before and after straightener treatment.
Methods: Forty hair samples were collected from female volunteers; each sample was divided into 2 groups; group A (before straightening) and group B (after straightening). Hair samples were washed then blow dried after that hair straightener was applied for 30 min then flat iron was done, hair samples were washed and blow dried. Each group was subjected to test their porosity and Fourier transform infrared spectroscopy examination to assess cysteic acid content.
Results: Hair porosity showed significant increase after straitening. Cysteic acid and disulfide content showed insignificant difference between both groups.
Conclusion: Hair straighteners may cause great damage to hair internal structures. So, proper choice of the material used and assessing the hair characters before straightening is necessary.

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Keywords: Hair straightening; porosity; cysteic acid.

1. INTRODUCTION

The hair is a natural fiber thread formed by α-keratin molecules, where two molecules coil to form an α-helix structure [1]. It consists of four layers: cuticle, cortex, intercellular cement and marrow, forming a very rigid structure that gives the thread strength and flexibility due to the concentration of sulfur from the amino acid cysteine [2].

The reasons for women seeking hair chemical treatments, such as dyes and straighteners include beauty, social acceptability, convenience and ease of management of the hair [3]. Hair straighteners are very popular around the world, although they can cause great damage to the hair [4]. The straightening process is based on disulfide bond reduction. The hair tress is shaped into the desired form and after the time necessary for the reaction, the oxidizing agent is applied to establish new linkages [3].

Following these straightening procedures, the hair must be washed with a specific shampoo in order to neutralize and close the cuticles of the hair shafts [5]. Considering that the physical properties of hair are directly correlated with its internal structure, with considerable changes resulting from treatments or conditions that alter this structure [6].

Thus, the use of adequate hair characterization methods is of great importance for the development of products that can improve the beauty of the hair fiber with minimal side effects [7].

The aim of the work was to evaluate the degree of damage that occur to the hair after chemical straightener treatment by assessing the change in hair porosity and hair cysteic acid content before and after straightener treatment.

2. SUBJECTS AND METHODS

This open label trial included 40 female volunteers from which the hair tresses were collected. They were selected from Outpatient Clinic of Dermatology and Venereology Department, Tanta University Hospitals. The study was performed from March 2018 to September 2018.

Inclusion criteria were 1) females 2) hair type: curly or straight 3) age from 18-35 years old 4) virgin hair or with previous chemical hair treatment as dyes.

Exclusion criteria were general contraindications (anemia, heart disease, respiratory insufficiency, renal failure, and liver failure), pregnancy, lactation and any dermatological disease affecting scalp hair as tinea capitis, alopecia areata …etc.

All female volunteers were subjected to 1) Complete history including present, past and family history 2) General and dermatological examination to exclude any systemic or dermatological disease.

Hair samples collected from selected volunteers under aseptic conditions (Hair samples were 10-15 cm long and 5-7 cm width). Each sample ranges from 7cm to 15 cm an average length allows hair processing. Samples were numbered starting from 1 to 40. Samples were kept in ambient room temperature till obtaining the straightener.

After being numbered each hair sample was divided into 2 tresses. Group A: Codes for tresses that weren't treated with straighteners and group B: Codes for tresses that were treated with straighteners.

2.1 Straightening Process

The process started with purchasing the suitable straightener in this study we used (ROSA PERFITA, SPHAIR COSMETICS). Ingredients were aqua, glyoxyloyl carbocysteine, glyoxyloyl keratin amino acids, glyceryl stearate se, dimethicone, behentrimonium Chloride, paraffinum liquidium, panthenol, macadamia ternifolia seed oil, Fruits extract methylchloroisothiazolinone, methylisothiazolinone, lactobionic acid, lactic acid, hydrolyzed collagen, sodium lactate, arginine, aspartic acid, glycine, glanine, serine, valine, threonine, proline, isoleucine, phenylalanine, benzyl salicylate, d-limonene and linalool.

Hair samples were cleansed carefully with shampoo then were blow dried with hot air. The whole straightening process was done by the aid of professional hair dresser. After being dried, each sample was divided into two parts A & B for ex. Sample 1 divided into 1A & 1B. A: codes for samples which not treated with straightener. B:

code for samples which were treated with straightener.

A suitable amount (covering the whole hair sample regularly) of the straightener was applied all over each sample. Samples were left for 45 min with the straightener on. Each sample was perfectly straightened using hot iron plate the one used here was Babyliss st326E slim protect at 230c degree for 10 min for each samples. Then hair samples were well cleansed using sodium and sulfate free shampoo (Every Strand Keratin hair shampoo). Samples then were blow dried with hot air until they were totally dry (Fig. 1).

2.1.1 Hair porosity assessment (Fig. 2)

Each sample was tested to determine its porosity by cutting small amount from each hair tress then putting it into a glass of water to assess whether it sank or not. The more porous the hair means the more it sinks also indicating the more damage. Samples were then classified according the degree at which it sank into: 1) Low porosity: the whole tresses float over the surface, 2) Normal porosity: part of the tresses floats and the other started to sink and 3) High porosity: almost all the tresses sank [8].

2.2 Cysteic Acid Assessment

For cysteic acid assessment we used Fourier transform infrared spectroscopy (FTIR) model tensor 27 made in Germany. For solid samples we add the sample to kBr powder with ratio 1:80 respectively to form a tablet. We put the sample in the pathway of the ray, make sure that humidity indicator lamb off, laser indicator lamb yellow and status indicator lamb green. Click sample signal channel to scan the sample in 60 secs, then treating the output using computerized program software then printing the results. The cysteic acid content of the hair samples was determined by estimating the ratio of the peak area of the S-S band (506 - 519 cm-1) divided by the peak area of the C-H band (1656 cm-1). Similarly, the disulfide content was assessed by estimating the ratio of the peak area of the S-O band (1040 cm-1) divided by the peak area of the C-H band (1656 cm-1) [9] (Figs. 3, 4).

2.3 Statistical Analysis

Organization, tabulation, presentation and analysis of data were performed by SPSS v25 (IBM Inc., Chicago, IL, USA). Quantitative parametric variables were presented as mean, standard deviation (SD) and range. They were compared by unpaired student's t- test. Qualitative variables were presented as frequency and percentage (%) and were analysed utilizing the Chi-square test or Fisher's exact test when appropriate. P value < 0.05 was considered statistically significant.

Fig. 1. Some hair tresses after being processed with straightener including straightened and non-straightened samples

Fig. 2. Porosity test

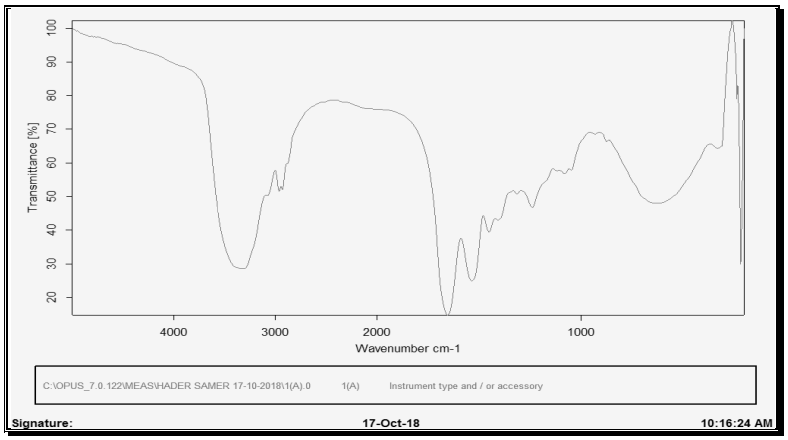

Fig. 3. FTIR report of cysteic acid measurement in hair sample 1A (before straightening)

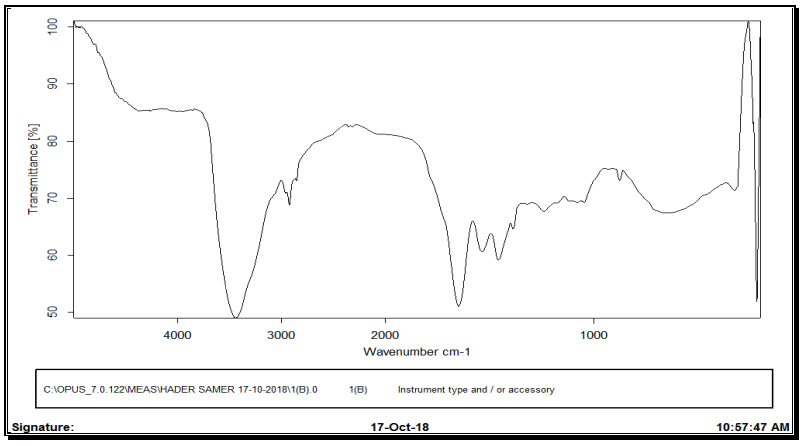

Fig. 4. FTIR report of cysteic acid measurement in hair sample 1B (after straightening)

3. RESULTS

This study included 40 female volunteers with different types of hair and their ages ranged from 18- 35 years old with mean 28.9 ± 7.3. After straightening all tresses became smooth and shiny.

According to porosity, in group A (before straightening) there were 30 hair samples with low hair porosity (75%), 10 hair samples with normal hair porosity (25%) and no hair samples with high porosity (0%). In group B (after straightening), there were 25 hair samples with low hair porosity (62.5%), 9 hair samples with normal hair porosity (22.5%) and 6 hair samples showed high hair porosity (15%). The comparison between the two groups showed significant difference (P = 0.039) (Table 1).

The cysteic acid measurement in hair samples was done using FTIR device. In group A (before straighteners) ranged from 0.098 – 0.651 with mean value 0.53 ± 0.222. In group B (after straightening) ranged from 0.063 – 0.667 with mean value 0.531 ± 0.237. The comparison between the two measurements in both groups showed insignificant difference (P = 0.168) (Table 1).

The disulfide content in group A (before straightening) ranged from 0.37 – 0.38 with mean 0.376 ± 0.005, the disulfide content in group B (after straightening) ranged from 0.37 – 0.39 with mean 0.378 ± 0.008. The comparison between the two measurements of both groups showed insignificant difference (P = 0.291) (Table 1).

4. DISCUSSION

Mechanical properties of the hair are attributed to the cortex that forms the main bulk of hair fiber. Curly hair is difficult to manage as desired and more prone to hair breakage and damage which cause psychological distress. The reasons for women seeking hair chemical treatments, such as dyes and straighteners include beauty, social acceptability, convenience and ease of management of the hair [10].

Chemical hair straightening is a process of changing naturally curly or kinky hair to permanent straight hair using chemical agents [11]. These hair products have been used by many women to attain cultural norms and standards of beauty that means long and straight hair [12].

Chemical relaxers produce a straight appearance by breaking the disulfide bonds of the hair [11]. However, this process weakens the hair shaft, as the rearrangement of disulfide bonds leads to structural damage of the hair shaft and decrease its tensile strength [13].

Complications of chemical hair straighteners with potent chemicals may be due to improper use by an unethical and unprofessional person or the use of chemicals with unacceptably high pH which results into scalp burns, infections, damage, breakage and hair loss [14].

Chemical straightening has increased in popularity because of its durability over thermal straightening and because it gives the hair a natural smooth, shiny look, more styling options for a longer time [15].

As regards to porosity, our result was in agreement with Dias [16] who mentioned that hair fibers are normally porous. Factors as straightening, dying and weathering make hair fibers more porous and cause more damage to hair cuticle and cortex.

On comparing the change in cysteic acid content in the investigated groups by using FTIR device, there was insignificant difference between group A and group B (P = 0.168). These results are in agreement with Leite and Maia Campos [17] who showed that the hair treated with straighteners didn't show oxidative damage as there was no change in the cysteic acid content, although they used formaldehyde and glyoxylic acid in their study.

Table 1. Clinical results of hair samples in group A (before straightening) and group B (after straightening)

		Group A (n = 40)	Group B (n = 40)	P value
Porosity	Low	30 (75%)	25 (62.5%)	**0.039***
	Normal	10 (25%)	9 (22.5%)	
	High	0	6 (15%)	
Cysteic acid		0.537 ± 0.222	0.531 ± 0.237	0.168
Disulfide		0.376 ± 0.005	0.378 ± 0.008	0.281

*Data are presented as mean ± SD or frequency (%) * significant as P value <0.05*

Regarding the disulfide content there was insignificant difference recorded on comparing the disulfide content in group A with that of group B (P = 0.291). This coincides with Leite and Maia Campos [17] who stated that treatment with hair straightener (formaldehyde) causes great damage to the hair structure in spite of there was no considerable change of the disulfide content in the examined sample.

According to Boga et al. [18] the breaking of the disulfide bond causes hair fibers weakening, and this in contrast with its healthy and shiny appearance after straightening but they stated that the cleavage of the cysteine and disulfide bonds during the semi-permanent hair straightening process with formaldehyde or glyoxylic acid doesn't cause change in their content due to the rearrangement of the disulfide bonds again after straightening to maintain the hair fibers in their new straight shape.

Our recommendations: 1) Further studies on large number of patients to assess the effect of hair straightening on hair shaft. 2) More physical characters of hair shaft need to be examined 3) Chemical characters of hair to be assessed regarding change in amino acids content after straightening. 4) Comparative studies to be done versus new products in the market called hair botox and hair fillers to detect their effect on hair. 5) Further studies to be done using SEM on a wide test group and also examination with transmission electron microscope.

5. CONCLUSION

Hair straighteners make hair looks smooth and straight also they cause great damage to hair internal structures. Hair porosity showed statistically significant change. Combination of hair dying, and straightening didn't cause great damage to hair than that occur with straightening alone.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT AND ETHICAL APPROVAL

The study was approved by the local ethical committee of Faculty of Medicine, Tanta University, Egypt. An informed consent was obtained from all volunteers after full explanation of full procedure and the purpose of the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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