

## Review Article

# What do we need to know about hair straightening?

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### ABSTRACT

Hair straightening is a popular hair procedure. The first hair straightening products were used for African hair. Various modes of hair straightening methods are currently being used. Temporary methods like blow drying and ironing are used for easy manageability of hair, both by modern men and women. Salon-based hair straighteners were initially permanent relaxers which, with time, evolved to formaldehyde-free hair strengthening procedures like hair Botox which is currently in trend. It improves hair manageability, increases hair strength and reduces frizz without producing much chemical damage to hair and by maintaining their natural waves, thereby producing a more natural look. We performed a thorough literature search on the topic in PubMed, consulted various hair stylists and beauty school professors prior to formulation of this article. The article aims at understanding the basic mechanisms involved in various hair straightening methods which helps us to advice patients on a wholesome care of hair.

**Keywords:** Hair straightening, Keratin, Cysteine, Formaldehyde, Brazilian keratin

### INTRODUCTION

Hair straightening is a very popular hair procedure around the world. A straight hair is considered as a sign of beauty by many. Hair straightening methods have also evolved over time. With urbanization, people are opting for various methods to increase manageability of hair, the most common being hair straightening. Though it's a very common procedure, it is associated with various adverse events. With new straightening methods coming in, the side effects are also coming down. A study done in Saudi Arabia revealed that 33.5% repeated their chemical procedure, for easy hair management being the commonest reason followed by nourishment and repair of hair.<sup>1</sup> We performed a literature search in the scientific database PubMed using the terms "straightening", "hair", "ironing", "Brazilian keratin" and "cysteine". We also consulted hair stylists from professional hair salons and also from beauty colleges prior to preparation of the article. The current

article focuses on various hair straightening methods and the chemistry behind it. It makes a dermatologist aware about the basic mechanisms involved, possible effects and thereby improve hair health.

### TYPES OF HAIR STRAIGHTENING

#### *Permanent*

Hair rebonding or Japanese/thermal reconditioning.

#### *Semi-permanent*

*Keratin/Brazilian blowout/Brazilian Keratin treatment*

This technique was introduced in 2003 in Brazil. It reduces the static electricity and makes hair more manageable.

### *Cysteine treatment*

They utilise carbocysteine-based products for the purpose of hair straightening.

### *Hair Botox*

It is a deep conditioning treatment that helps to restore hair damage. They contain a cocktail of nourishing ingredients such as vitamins, amino acids, glyoxylic acid, collagen complex, ceramides and many more, which forms a protective coat on hair.

### *Temporary/non chemical*

They last only until the next wash. Hair has to be pre-wetted, to break the hydrogen bonds of keratin, thus permitting temporary opening of its original structure. Rapid drying with the hair dryer maintains the flat shape of the strand. The application of a hot iron mechanically fixes the shape of already straight wet hair. This is usually done by men and women as a home-based procedure using blow dryer straightening iron etc.

## **CONSTITUENTS OF VARIOUS HAIR STRAIGHTENING PRODUCTS**

Straightening products are widely used to change hair shape. Chemical based hair relaxers are broadly classified as “Lye” relaxers, no-lye relaxers and “thio” relaxers.<sup>2</sup>

### *Lye relaxer*

They contain sodium hydroxide as an active ingredient and are also known as soda- containing straighteners. They act by the lanthionization reaction, in which the hydroxyl ion breaks the disulfide bonds generating lanthionine. Here, disulphide bonds undergo rearrangement and cysteine is ultimately converted to lanthionine. This causes irreversible hair straightening.<sup>3</sup> They are extremely alkaline with a pH of 13–14 with a higher scalp irritation potential. The transformation of cystine into lanthionine and a high pH causes weakening of the hair fibre, through a decrease in mechanical strength and higher protein loss.<sup>4,5</sup>

### *No-lye relaxers*

They contain lithium, guanidine hydroxide, or ammonium thioglycolate. They are known as non-hydroxide straightening products. They are less irritating compared to sodium hydroxide.

### *Straightening with reductive agents (thio-relaxers)*

Ammonium thioglycolate (AT), ethanolamine thioglycolate, cysteamine hydrochloride, glycerylmono-thioglycolate, ammonium sulphite, ammonium bisulphite. AT is the most common and has a pH of 9-9.3.

### *Thioglycolic acid and its salts*

They include ammonium thioglycolate (AT), aminomethyl propanol thioglycolate, and ethanolamine thioglycolate. Like hydroxides, thiols also swell the hair shaft, but with no lanthionization reaction. It selectively weakens the hair's cystine bonds and reduces the disulphide bonds instead of disrupting the entire protein. In the procedure with ammonium thioglycolate, the disulphide bonds are converted to sulphhydryl groups to allow the mechanical relaxation of the protein structure of hair fibres following which the thioglycolate is oxidized (neutralized) with ammonia, monothanolamine, sodium hydroxide or other oxidising agents. If a hot iron is applied during the process, the permanent straightening can be achieved. This is the basis of the process called “japanese hair straightening or thermal reconditioning.” The use of thioglycolate causes less protein loss than hydroxides whereas oxidising agents like hydrogen peroxide may cause the hair colour to fade. Hair conditioning substances may be added to thioglycolate straighteners in order to minimize hair damage.

### *Straightening utilising formaldehyde*

This is used in methods like Brazilian Keratin Treatment. Formaldehyde and other aldehydes are not straightening products but act as a cross linking agent. Water initially breaks hydrogen bonds of the keratin molecule, with hair wetting. The formaldehyde then forms crosslinks with the keratin filaments which fixes the hair as straight. The light that strikes the hair reflects from the realigned keratin filaments and create good shine from hair post procedure. The aldehydes are compatible to every other hair treatment, such as bleaching, permanent dyes and lye/no-lye relaxing.

### *Glyoxylic acid and its variants*

Glyoxylic acid (GA), also called formic acid or oxoacetic acid, is an organic compound. They are being promoted as “formaldehyde –free” but act as formaldehyde releasers when subjected to high temperatures.<sup>6</sup> GA straightening have semi-permanent results, which lasts for only up to five to ten washes. GA penetrates through cuticles and acts on the hydrogen bonds and the amino acid tyrosine of the cortex. It causes no break in the disulphide bridges, but a change in the shape of these bonds and forms a polymerized structure in the hair shaft, leading to straightening of hair. The temperature is highly associated with this process, because higher the temperature, the more the formation of these products. Examples of glyoxylic acid derivatives are glyoxyloyl carbocysteine, glyoxyloyl keratin aminoacid oxoacetamide.<sup>7</sup> Despite the film-forming effect, giving it a shiny appearance, this substance disturbs the integrity of the keratin and the tensile strength of the shafts, thereby making it more fragile.

### ***Straightening using carbocysteine- based compounds***

They include glyoxyloyl carbocysteine or oxoacetamide carbocysteine. It has no effect on hair keratin. Carbocysteine hair treatment represents the combination of glyoxylic acid + cysteine + acetic acid.<sup>8</sup> Glyoxyloyl carbocysteine, the most commonly used ingredient in Cysteine treatments, has a pH nearer to our hair and scalp and is thus less damaging and they also release a little formaldehyde in the ironing step. Though the straightened hair in Cysteine treatment is not as poker straight as compared to conventional relaxer-based straightening or a Brazilian keratin treatment, it gives more shine to the hair compared to the other two.

### ***Keratin based particles***

The synthetic hydrolysed liquid keratin penetrates quickly to the cortex and reacts with the keratin of human hair. Formaldehyde released during heating helps in fixation of hydrolysed keratin in the natural keratin of the hair.<sup>6</sup> This produces a water-proofed film around the hair and seal the cuticles, improving the shine and smoothness of virgin and bleached hair. This film is not so protective since the shaft remains fragile and susceptible to fractures after minimal trauma.<sup>9,10</sup>

### ***Other contents in straightening formulation***

**Silicone:** Silicone forms a uniform, continuous, and hydrophobic coat improving resistance and reducing surface tension of the styled hair. They substitute the natural sebum, without providing an oily feeling, and reduce the damages caused by oxidizing and straightening treatments. Example- polydimethylsiloxanes, dimethicone.

**Proteins like hydrolysed proteins, amino acids.**  
**Conditioning agents:** Shea butter, cocoa seed butter etc.  
**Additives like fragrance.**

## **PROCEDURE**

The hair is examined prior to selecting the ideal relaxer for a consumer, the strength and type of relaxer determined based on the coarseness, degree of curliness, porosity and previous treatments done. The hair then is shampooed to remove sebum or products that might interfere with the action of the straightening solution. The hairline and ears are protected with petrolatum or cotton to avoid the highly alkaline solution to cause burns on skin. The hair is separated into sections. Chemical relaxers are applied on clean hair. Once the cream is applied, it is smoothed section-by-section until the hair is straightened. The amount of time the relaxer is left on the hair is determined by the hair porosity, thickness and the manufacturer's instructions, following which the hair is rinsed. The relaxer should be completely rinsed out before the hair is shampooed. Finally, a neutralizing shampoo is used to bring the pH back to normal and to close the cuticle.

For hair Botox, the hair is washed, skipping conditioner, with a clarifying shampoo to remove any residue on your hair and open your hair cuticles. Afterwards, the mixture will be applied and left on for roughly 45 minutes, before being washed off with a gentle, low or sulphate-free shampoo, blow-dried and typically, sealed with straighteners.

To prevent irritation, hairdressers are advised to wear gloves while the procedure is being done.

## **ADVERSE EFFECTS**

Despite being a very common procedure, hair straightening is associated with multiple side effects. The no-lye relaxers are less irritating to the scalp than lye relaxer (sodium hydroxide). The most common adverse effects reported after chemical hair straightening were frizzy hair, dandruff, hair loss, thinning and weakening of hair, greying of hair and split ends.<sup>11</sup> The side effects are not seen just for clients but all also for hairstylists. Evidence of cancer among hairdressers have been described by many.<sup>12</sup> It was first reviewed by the International Agency for Research on Cancer (IARC) which reported an increased risk of urinary bladder cancer, lung cancer, upper aero-digestive tract cancer, breast cancer, and non-Hodgkin's lymphoma in these professionals.<sup>13</sup> Hairdressers have also demonstrated an increased frequency of DNA damage.<sup>14</sup>

### ***Allergies***

Irritant and allergic contact dermatitis are common. It can be caused by formaldehyde, fragrance, parabens, quaternium-15 (a formaldehyde donor), methylisothiazolinone etc.

### ***Hair damage***

Weathered and chemically treated hairs can get worn off of 18-MEA in cuticle which leads to hair fibre fracture and makes the hair hydrophilic. Chemical treatments make hair more porous and this usually occurs if the hair is exposed to straightening chemicals for long time or high concentration.<sup>15</sup> The pH of the straightening formulation also affects the hair strength wherein a low pH can cause a better straightening but lesser hair strength and vice versa.<sup>7</sup> Heat can cause denaturation of various hair proteins and cause hair damage. However, it was found that using a hair dryer at a distance of 15 cm with continuous motion causes less damage than drying hair naturally.<sup>16</sup>

### ***Alopecia***

Scalp inflammation and scarring alopecia have been reported with both lye and no-lye relaxers.<sup>17</sup> Telogen effluvium may occur, usually because of excessive or improper use of straightening agents.<sup>18</sup> High-tension hairstyles are best avoided on relaxed hair to prevent traction alopecia.

### **Repetition of procedure**

Most of the hair straightening needs to be repeated regularly as the newly grown hair will be having a completely new texture and appearance compared to the old. Careful application over the new growth is needed as overlap over the straightened hair causes excessive breakage. Semi-permanent procedures like hair Botox lasts for only few washes.

### **Short term side effects**

They include scalp itching during the procedure and burning sensation in eyes, nose, and throat have been reported.<sup>19</sup>

### **Carcinogenicity**

Various agents like formaldehyde, being a known carcinogen has made various regulations on the use of formaldehyde in hair products.<sup>20</sup>

### **Others**

Formaldehyde causing urticarial have been reported.<sup>21</sup>

## **COLOURING WITH STRAIGHTENING**

Colouring either with hydroxides or with thioglycolate, may cause hair damage and breakage in chemically straightened hair as both are highly alkaline. Therefore, the demi-permanent hair dyes are preferred over the permanent ones when both colouring and straightening are combined. Ammonium thioglycolate or guanidine hydroxide caused a small increase in protein loss, suggesting that these straightening products could be better than hydroxides for individuals wishing to combine both treatments.<sup>22</sup>

But with current methods like hair Botox, we can combine both without causing much hair damage. It is not recommended to dye your hair right after a hair Botox treatment and a gap of at least two weeks should be given before hair colouring. The chemicals present in permanent dyes can wash off the coat formed after hair Botox. Hence it is better to do Botox post colouring if the client wishes to combine both. But a Botox can affect the tone of already coloured hair.

## **HAIR STRAIGHTENING IN PREGNANCY**

Chemical hair straightening is usually not recommended in pregnancy. It has been found that children exposed to hair straightening compounds prenatally especially formaldehyde, perchloroethylene, acetaldehyde increases risk of developing Wilm's tumour and early age of onset of leukemia.<sup>23,24</sup>

## **CONCLUSION**

Equipped with this knowledge, we as dermatologists will be better able to counsel our patients on the appropriate use of relaxers, helps to choose the ideal straightening method depending on the need and hair condition, time the procedure and educate them on care of processed hair.

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