

## Hair breakage index: An alternative tool for damage assessment of human hair

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### Synopsis

Improper hair care, mechanical abrasion, sun damage and chemical treatment changes the physical and morphological characteristics of hair. Several methods involving microscopic techniques, protein loss and assessment of tensile properties of the hair are generally used to evaluate the extent of damage caused. These are also used to determine the protective effect of hair care products. In the present investigation, the hair breakage index (HBI) was used as an alternative tool to determine the change in the properties of hair on weathering. HBI is a measure of the diameter of hair in a given cross sectional area of a marked region of hair on the scalp. The hair diameter changes as we progress towards the tip of the hair due to breakage. The ratio of the diameter of hair bundle in the distal region to the diameter of hair bundle in the proximal region from the scalp is used as an indicator of hair breakage. Higher HBI value is an indicator of hair damage.

A study was conducted for duration of 16 weeks to assess the effect of weathering due to grooming practices on HBI values. The HBI and break stress for a group of 30 subjects were measured at baseline and at the end of 16 weeks (NU). Since Coconut oil (CNO) is known to have a positive benefit on tensile properties of hair, another matched group of 30 subjects who oiled their hair daily with CNO was used as a positive control (CNO). The HBI and break stress for this group were also measured at the baseline and after 16 weeks. It was observed that the HBI significantly increased in the NU group versus the CNO user group. The break stress also significantly decreased in the NU group suggesting its correlation with the HBI data. This study demonstrates the usefulness of HBI as a simple and effective tool for determining hair damage and its protection by different hair care products.

### INTRODUCTION

Human hair is a keratin containing appendage that grows from the hair follicle. It predominantly contains 65-95% of proteins, the remaining constituent being water, lipids (sterol, free fatty acids and polar lipids), sugars, pigments and nucleic acids (1,2). The human hair is a reactive substrate, whose structure and physio-chemical properties are of great interest in relation to environmental factors and cosmetics applied to it. Several factors like improper hair care, mechanical abrasion, solar radiation and chemical treatments, change the physical and morphological characteristics of hair.

A variety of methods have been used for the assessment of hair damage, including measurement of tensile property and chemical changes like protein loss (3). Most of the methods

are time consuming and are performed *in vitro*. In the present study, the extent of hair damage was determined by a cross-sectional trichometer which allowed a quick and non invasive assessment of hair and is time saving.

The cross-sectional trichometer is a new device that enables the measurement of hair loss and hair growth, or simply measures the quantity of hair that is present in a particular area of scalp. It works on the principle that there is a change in hair diameter in the selected area of scalp due to breakage by different practices like washing and combing. These grooming practices damage more to the distal portion of the hair strand as compared to the proximal end of hair. Therefore, the diameter in the distal end will be lower as compared to the proximal end. This difference is represented by HBI which is measured as follows

$$\text{HBI} = (\text{distal cross-sectional area} / \text{proximal cross-sectional area}) \times 100$$

In the present investigation, the HBI was used as an alternative tool to determine the extent of protection offered by the application of CNO versus the NU group. Increase in HBI value is an indicator of hair damage. Two groups of female volunteers in the age group of 20-30 years (30 each) were included in the study. One group received daily application of CNO for 16 weeks and the other group did not receive any oil application. The subjects continued with their normal hair maintenance regimen of shampooing and combing their hair during the study period. The subjects assigned to the coconut hair oil group used the oil before shampooing as a pre-wash conditioner.

The effectiveness of this method was evaluated by comparing the HBI values with the changes in tensile parameters and a correlation between these two techniques was drawn.

## MATERIALS AND METHODS

### STUDY DESIGN

Sixty volunteers (female) in the age group of 20-30 years were included in this study. These were subjects who did not use hair oil but used a shampoo for cleansing hair. They also did not use any other conditioners or styling products. These subjects were divided into two groups of 30 each. One group applied coconut oil daily while the other group did not apply any product. The primary assessments included measurement of HBI at the baseline and after 16 weeks of treatment. Few hair fibers were collected during each visit to determine the break stress of hair.

### DETERMINATION OF HBI

HBI was measured using a hair check instrument, which is a mechanical device that precisely measures the cross-sectional area of a bundle of hair on the scalp. During this study, the HBI of a specific area of the scalp was determined using a marking template in order to measure the HBI of same area after treatment. Initially, the hair fibers around the marking template were separated carefully and then the measurement was taken 1 cm

away from the scalp (Proximal reading). The second measurement was taken 7 cm away from the first measurement to get the distal reading. The protocol for determining HBI is represented in Figure 1. The change in diameter determines the HBI values. All the measurements were performed at 21°C and 60% relative humidity.

#### DETERMINATION OF BREAK STRESS

Break stress of hair was measured using Instron tensile tester (URM/LRX Plus). Hair fibers (3 cm) were mounted on Instron crimps and were stretched to break. The hair diameter for determining the was measured using a folliscope. A load of 100N was applied to the fibers and the operating speed was 10 mm/min. The Break Stress of the hair was determined from the stress-strain curve. The measurements were performed at 21°C and 60% relative humidity.

## RESULTS AND DISCUSSION

#### HAIR BREAKAGE INDEX

The HBI values were calculated both at the baseline and after 16 weeks for both the groups. The mean HBI values at the baseline were 9.25 and 12.23 for NU and CNO groups, respectively (Table 1). The HBI value increased by 9.5% in the NU group which is an indicator of hair damage. However, the HBI value decreased by 41.8% among CNO user group. After daily treatment with CNO for 16 weeks, the HBI value was significantly decreased in the CNO user group as compared to NU ( $P < 0.05$ ). The decrease in HBI value is an indicator of the increase in hair diameter or less breakage in CNO user group. The lowered hair breakage is assumed to be an outcome of the conditioning benefits of the oil and which could be attributed to the reduction of the combing force during

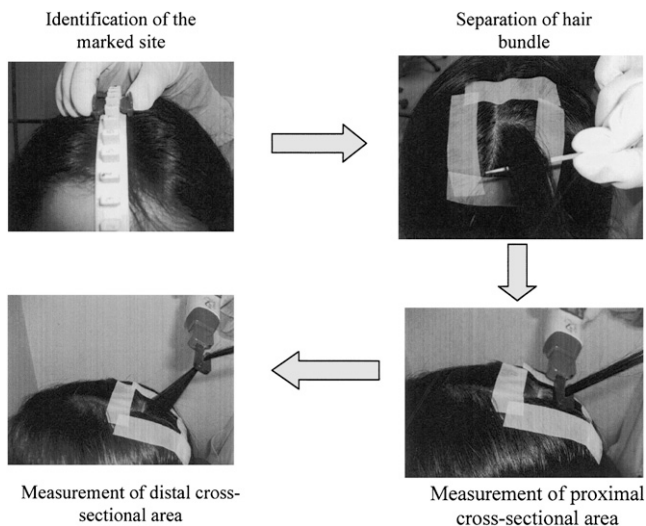


Figure 1. Methodology for assessment of HBI using the hair check instrument.

**Table I**  
Hair Breakage Index before and after the Application of the Product

User group	Hair breakage index (%)	
	Mean $\pm$ SEM*	
	Baseline	After 16 weeks
CNO	12.23 $\pm$ 1.13 <sup>a</sup>	7.12 $\pm$ 1.26 <sup>b</sup>
NU	9.25 $\pm$ 0.92 <sup>a</sup>	10.13 $\pm$ 1.63 <sup>a</sup>

Values indicated by different letters in superscript in the same column and same row are significantly different ( $p < 0.05$ ).

\*SEM: Standard error of the mean.

daily grooming practices. CNO is mostly a triglyceride of lauric acid and is hydrophobic in nature. Application of CNO as a pre-wash conditioner coats the hair surface and prevents the penetration of water into hair fiber. A small part of it is absorbed into the hair during washing when the fiber is swollen. Introduction of the hydrophobic component reduces the swelling of cuticle and hence reduction in protein loss. Therefore, CNO users had less hair damage as compared to the non-users.

#### BREAK STRESS

Similarly, the break stress was decreased by 9.55% in NU group and it was increased by 1.35% in CNO group. The break stress of hair was significantly increased in the CNO user group versus NU after 16 weeks of treatment ( $P < 0.05$ ) (Table 2). Penetration of oil into the hair cuticle prevents water from entering into the fiber. CNO also helps in the plasticization of hair fiber thus leading to increased break stress. In the NU group the break stress is decreased suggesting its damage due to daily grooming practices.

The results of the study indicates that due to daily grooming practices the hair is undergoing some degree of damage which was reflected from the values of HBI and tensile strength. Application of CNO prevents the damage and thus could be used regularly in order to maintain healthy and beautiful hair.

**Table II**  
Break Stress of Hair before and after the Application of the Product

User group	Break stress of hair (MPa)	
	Mean $\pm$ SEM*	
	Baseline	After 16 weeks
CNO	198.70 $\pm$ 7.4 <sup>a</sup>	201.4 $\pm$ 5.9 <sup>a</sup>
NU	20.20 $\pm$ 5.8 <sup>a</sup>	182.00 $\pm$ 5.3 <sup>b</sup>

Values indicated by different letters in superscript in the same column and same row are significantly different ( $p < 0.05$ ).

\*SEM: Standard error of the mean.

## CONCLUSIONS

- HBI can be used as a tool for assessment of hair damage.
- It offers a fast and reliable non destructive option against the normal destructive methods for assessment of hair damage.
- The advantage of this method over the other hair damage assessment techniques is that it can performed directly on human volunteers and is helpful in evaluating the efficacy of the product in clinical trials.

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