Hair Breakage in Normal and Weathered Hair: Focus on the Black Patient

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Hair breakage and fragility are a large problem for many patients as well as a treatment challenge to the dermatologist. Understanding the factors that lead to acquired hair shaft fragility and breakage is paramount to recommending appropriate treatment to affected patients. African or Black hair is known to be more affected by breakage with easily observed fragility *in vivo*. To date there are no known structural or chemical differences in Black hair as compared to Caucasian or Asian hair that explains this observed fragility. This review explores the impact of hair care practices on the development of hair breakage with a focus on patients of color. The examination and recommended ancillary testing for the process are discussed, and advances in the measurement of mechanical fracture of human hair are reviewed.

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INTRODUCTION

Hair fragility on the scalp can take many forms in patients who seek the dermatologist's help. Breakage in the hair shaft is typically something that patients notice long before they seek medical or even the hair stylist's counsel, but there are many causes of breakage that patients do not consider, and treatment is often baffling to the layperson. When patients do seek medical intervention, the chief complaint may be, simply, hair loss. While increased hair shedding may be noted by the patient, there is not usually a thorough examination of the shed hairs, and therefore no clear understanding of the kind of hair problem they are experiencing. Often, the patient will be underwhelmed with the diagnosis of hair fragility or breakage, as the observed hair loss has led them on a hunt for internal causes or other more obscure reasons for hair loss. Another complicating factor with the initial evaluation of a patient with hair breakage may be that there have been unsuccessful attempts at self-treatment that may have caused worsening of the condition.

Hair breakage in the African-American patient may be more of a challenge than the same process in the Caucasian patient, since the hair shaft of the African-American patient appears innately more fragile and hair care practices are often extensive and complicated, including many stylist-recommended and home-based products. This review will attempt to elucidate the typical causes of hair breakage with a focus on the Black patient, explain the challenges that may be encountered in patients of color with hair breakage, review technical means of measurement of hair shaft fragility, and discuss potential approaches to improve the problem medically.

BASIC PRINCIPLES OF HAIR SHAFTS AND RACE

The African-American hair shaft is elliptical or flattened in cross-section and spiral or tightly curled in tertiary structure (Syed *et al.*, 1995). Within the black race, significant variations may be seen, but in most African Americans, the curled hair does not emanate from a straight follicle. Instead, the follicle where the hair is formed is just as curved as the hair itself (Lindelof *et al.*, 1988). Relatively, little is known about how the structure of African-American hair impacts function. Bernard (2003) performed *in vitro* experiments comparing the growth of curly and straight hair. He found that curled hairs dissected out of the scalp and placed in culture continued to grow in curled fashion, suggesting that the shape of the hair may be intrinsically programmed by the lower half of the hair follicle with or without the usual dermal environment. There also appears to be less moisture in the hair shaft of African patients than in Caucasians. Franbourg *et al.* (2003) found that African hair shows the greatest percentage of cross-sectional variability compared with Caucasian and Asian hair.

CAUSES OF HAIR BREAKAGE AND FRAGILITY

Hair shaft abnormalities are congenital or acquired alterations characterized by changes in color, density, length, and structure of the hair shaft. There may be a genetic predisposition to abnormalities or exogenous factors that lead to the problem. Localized or generalized forms of the process can be seen. Only some of these abnormalities confer fragility to the hair shaft. Abnormalities such as trichothiodystrophy (a genetic process associated with reduced cysteine-rich proteins and increased hair shaft fragility), pili torti,

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monilethrix, and other such diseases provide a wealth of information on hair shaft biology, but will not be discussed in this focused review. This review will discuss only those abnormalities that produce an acquired clinical fragility.

African-American women are particularly at risk of hair breakage, due, in part, to the various hare care practices that weaken the hair shaft as well as the dry nature of the hair. Khumalo *et al*. observed the apparent increased fragility in black African hair and considered if the fragility was related to an underlying trichothiodystrophy. These authors compared cystine-rich protein distribution in the hair of black Africans to Causcasian and Asian hair using transmission electron microscopy and silver stains (Khumalo *et al*., 2005). The results showed similar distribution of cystine-rich proteins in all ethnicities, suggesting that the excessive structural damage observed in African hair shafts is consistent with physical trauma and/or, as yet, undiscovered other structural abnormalities and not a trichothiodystrophy-like process. This underscores the need to uncover the history of hair care practices in determining etiology of hair breakage.

Specific questioning as to the combing and brushing habits, washing frequency, drying process used, hair care products used and how they are applied, and finally, any chemical process performed on the hair must be researched in a chronological fashion from at least 6 months before the first observed hair breakage to the current time. While simple combing may seem innocuous compared to the other hair care practices listed, the impact of combing has been studied. Two evaluations of combing (though not performed on African or Black hair) show that extension or impacting of hairs with flaws on other hairs causes short fiber fragmentation, and longer segment breaks may occur secondary to natural flaws such as fiber twists, cracks, knots, or chemically abraded hair (Robbins, 2006a, b).

Hair care history

It is important that the physician obtaining the history of breakage is familiar with the various hair care regimens that are used by the patient, or treatment recommendations will suffer greatly. The major hair care practices that cause hair weathering and ultimately, breakage include heat-related straightening of the hair, chemical straightening agents, permanent hair color, and drying agents used to keep the hair in place.

Heat. Heat is most often used by African-American women who want to thermally straighten the hair without a permanent straightening process. In this form of straightening, a metal comb is heated to high temperatures (150–500°F) by a heat source such as a small electric warmer or hot flame. Washed and dried hair is treated with an ointment-based lubricant and the hot comb is slowly pulled through small sections of hair. This process temporarily rearranges hydrogen and disulfide bonds within the hair shaft (Scott, 1988; Nicholson *et al*., 1993; DeVillez, 1994). The hair remains straight until it is exposed to moisture. On rewetting, all signs of the hot combing effect are lost and the hair reverts back to its original state. More recently, electric flat straightening irons fashioned similarly to curling irons have become popular with many women (of all ethnicities), but still heat the hair to high temperatures to achieve the straightened style.

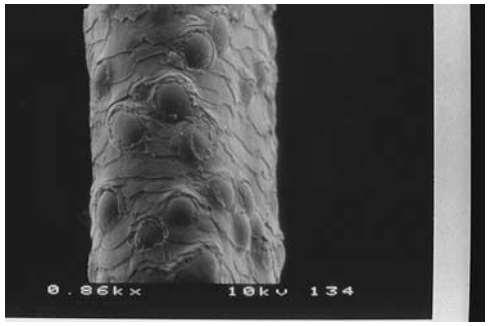

Figure 1. Scanning electron micrograph of bubble hair with the gas containing damaged areas simulating bubbles on the hair shaft (photo courtesy of P&G Beauty).

Thermal straightening of the hair is not as popular as it once was, because the more convenient and longer-lasting option of chemical straightening has become widespread. Common problems with thermal straightening include overheating of the hair shaft causing weakening and breakage (Scott, 1988; Nicholson *et al*., 1993). An entity called ''bubble hair,'' first reported in 1986, is known to occur secondary to overheating of the hair shaft (Figure 1) (Brown *et al*., 1986). Bubble-like areas in the hair shaft are seen with light microscopy and scanning electron microscopy with gas-containing cavitations in the hair shaft (Detwiler *et al*., 1994). To avoid hair shaft damage, a well-trained professional should perform the procedure. Keeping hot comb treatment to a maximum of once weekly, only hot combing clean, dry hair, and obtaining regular trims of damaged ends will help to prevent damage from the procedure. If damage continues, the patient should suspend thermal straightening, cut the damaged hair, and use moisturizing shampoos and conditioners.

Chemical straightening agents. African-American women began to utilize chemical relaxers regularly in the 1960s, and this has become the most common method of hair straightening used by African-American women currently. Chemical relaxers used on the hair in African Americans contain sodium, potassium, or guanine hydroxides, sulfites, or thioglycolates. All of these chemicals work to produce a straight appearance by affecting the cysteine disulfide bonds of the hair. This process weakens the hair shaft, as the rearrangement of disulfide bonds does not occur without structural damage to the shaft and decrease in tensile strength compared to untreated hair (Khalil, 1986). While avoidance of severe damage is possible with the use of professionals applying the chemical and maintaining at least 6–8 weeks between reapplication to new growth, the severity of improperly formulated chemical relaxers is well-known. In 2000, 95% of 464 patients reporting use of a commercial hair-straightening product had hair breakage and hair loss after use of this product (Swee *et al*., 2000). The severity of the adverse effects from this particular product prompted the FDA to remove it from the market.

Other agents. Other products used to minimize styling time, decrease weather-related hair frizzing, and restrain the hair in a neat fashion include gels, sprays, and spritzes. Many patients are unaware that use of these products may lead to some fragility of the hair shaft during manipulation of the hair with the product in place. Decreased combing and grooming of the hair, once such a product is in place, may minimize breakage until the product is fully washed out.

Twisted hair styles. Often patients will notice breakage and discontinue use of all chemical and heat processes in an attempt to minimize further damage. One would assume that this would be helpful, but if the patient is African American and selects a natural twisted style such as that used in versions of dreadlocks or twists, damage may continue at the twist site. In a study of the tensile properties of twisted hair fibers, Dankovich *et al*. (2004) showed that only at low and moderate twist levels, is tensile mechanical property of human hair recoverable. While this study was not conducted using African hair, the recovery of tensile strength may be less probable in this population. It is important to help patients understand appropriate styles for their hair type and extent of damage. While some may do well with a twisted style, those with significant damage may only improve by cutting the hair into a short style requiring little maintenance.

Performing the exam

Once hair breakage is suspected as a diagnosis and the historical information is gathered, an examination consisting of a visual survey, pull test, with or without microscopic examination of hair shafts is necessary. Visible patches of short hair among longer hair should be specifically examined for breakage with a pull test of the affected hair and the hair surrounding the patches. Diffuse pull testing of hairs in each quadrant of the scalp can be performed looking for a significant number of hairs to break off mid-shaft. Microscopic examination of these broken hairs may demonstrate uneven breakages that resemble broom stick-like projections of cuticular material, suggesting the presence of one of the most common hair shaft abnormalities seen, an entity called ''trichorrhexis nodosa'' (Figure 2). Certainly, light microscopy is one of the easiest, least invasive, and least expensive means by which to examine hair samples and aid in diagnosis (Smith *et al*., 2005).

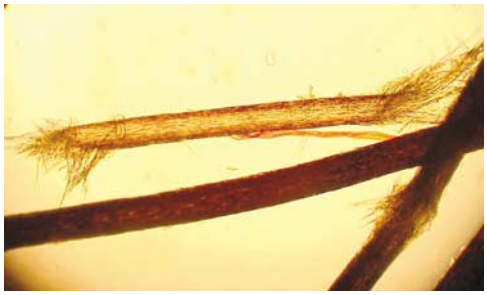

Figure 2. **Light microscopy photo of broken hair shaft with trichorrhexis nodosa changes.** Original magnification $\times 40$.

One important differential diagnosis of weathering-related hair fragility that must not be forgotten is tinea capitis. It is not uncommon for African-American adult women to present with this primarily children's disease, and a potassium hydroxide test in the office is a quick and easy way to rule out this diagnosis in areas of breakage that are not completely consistent with weathering (Silverberg *et al*., 2002).

Beyond the office exam

Various laboratory methods exist to measure the strength and elasticity of the hair shaft. While these methods may be less likely to be useful in the clinical setting, they are none-the-less helpful in understanding the properties of hair damage. Light microscopy, polarized light microscopy, and scanning electron microscopy have been use to elucidate the structural changes seen in fragile hair shafts (Itin and Fistarol, 2005). Khumalo *et al*. (2000) performed a survey of over 2000 hairs from 12 African volunteers with untreated hair that had not been cut for one year or more. Compared to Caucasian and Asian hair samples, those from the African volunteers exhibited more knots (10–16 *vs* 0.15%) and appeared broken compared to hair shafts from other ethnic groups. Scanning electron microscopy showed repeated breaks of the shaft.

A number of other tests can be performed on hairs gathered from volunteers to measure elasticity and fragility of hairs. For the most part, these tests have been carried out for the purpose of clinical study using Caucasian volunteers. These tests include stretching hairs on a load-extension apparatus, transmission electron microscopy, repetitive combing of hair swatches, and flexabrasion testing. Stretching hairs on a load extension apparatus has uncovered significant information about the mechanical stress of fracture of the human hair, but is likely not as helpful in mimicking the true life conditions leading to hair fractures (Swift, 1999). More consistent with *in vivo* hairs are tests such as repetitive combing of hair swatches and flexabrasion testing. The flexabrasion testing consists of hairs drawn at 90° over a wire against a weight attached to the free end of each fiber of hair where the fatigue time to fracture time is measured (Leroy F, Franbourg A, Grognet JC, Vayssie C, and Bauer D (1995) Flexabrasion is a new test for predicting human hair resistance. Poster presented at the First Tricontinental Meeting of Hair Research Societies, Brussels, October 8–10.). There is good correlation between the combed-treated swatches of hair and the flexabrasion methods, suggesting a powerful measure of hair fracture and tensile strength. It is not known if the inherent fragility exhibited by African and African-American hair can be measured adequately using these models, as they have not been tried extensively in these populations.

SUMMARY

Hair fragility leading to breakage can occur due to genetic predisposition, weathering from various hair care practices, and as a typical state such as that experienced by many African or Black patients. Understanding the entity of hair breakage in the context of varied combinations of hair care practices is paramount in treating patients appropriately, allowing recommendation of protective hair products that

Table 1. Evaluation of hair shaft fragility and breakage

Necessary to evaluation
Gather history of hair breakage and hair care practices
Visual examination of scalp, general and localized
Pull test examination of hair shafts
Microscopic examination of hair shafts
Adjunct measures
Polarized light evaluation of hair shafts
Scanning and or transmission electron microscopy
Hair swatch combing
Load extension apparatus
Flexabrasion

can minimize fragility and breakage, while disallowing practices and products that put fragile hair at further risk. Testing of hair shafts for acquired forms of hair breakage can be as simple as a visual survey and pull test or as complicated as transmission electron microscopy and flexabrasion testing (Table 1). The physician must play the role of detective in finding out the potential exogenous cause of hair breakage, determining the appropriate level of testing, and finally recommending a course of treatment.

Innate fragility in the hair shafts of African-American patients makes it difficult to understand where the natural state ends and the disease state begins. While some avoidance of known exogenous factors may help to minimize breakage in this population, testing of Black hair on a more appropriate apparatus for hair type must be performed to set standard measurements. This will allow analysis of the natural and treated hair shafts of African-American patients, ultimately improving diagnostic criteria of breakage in this population as well as measure the effect of protective hair products in the treatment of these patients.

CONFLICT OF INTEREST
The author is a consultant to Johnson & Johnson and P&G Beauty and received an honorarium for consultant's services from Procter & Gamble towards the preparation of this article.

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