INTRODUCTION

Alopecia is a common dermatological disorder of the hair follicles. It is neither life-threatening nor painful and has few physically harmful effects. However, it may lead to psychological consequences, including high levels of anxiety and depression. Patients with different types of alopecia may begin to avoid public situations and can experience excessive fear or embarrassment when their lack of hair is noticed. Medical treatment for the disorder has limited effectiveness, and the failure to find a cure can leave patients very distressed. Although dermatologists are experts in managing scalp and hair diseases, hair cosmetics are also an important tool that can help to improve patient’s treatment adherence. Moreover, hair cosmetics can reduce emotional suffering that can lead to personal, social, and work-related problems. Knowledge of hair cosmetics and esthetic procedures as well as of the hair shaft structure and physical behavior is indeed relevant in today’s medical practice.

Recently, cosmetic technology has begun to use the electrostatic adherent powder of organic hair fibers to the human hair shaft, enabling the development of some innovative hair cosmetic products known as reconstructive hair fibers.

Scanning Electron Microscopy and X-ray Microanalysis of Reconstructive Hair Fibers

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ABSTRACT

Background: Reconstructive hair fibers are an innovative tool in cosmetic dermatology based on electrostatic adherent powder which bonds to the hair shaft and can disguise hair loss in men and women. Aim: This study aims to analyze and compare five different brands of organic hair fibers. Materials and Methods: A scanning electron microscope (SEM) was used to obtain amplified images of samples to study their shape and morphological structure. X-ray microanalysis was performed to study the chemical composition of reconstructive hair fibers. The five samples were tested in patients attending a trichology unit of a tertiary hospital. Results: The main component in hair fibers products 1 (Blum Secret™) and 3 (Keratin™) was cotton (cellulose of vegetal origin), while product 2 (Viviscal™) was made of a vegetal keratin. All three samples appeared as parallel-arranged fibres on the scanning electron microscope. The X-ray microanalysis showed an organic polymer mainly composed of C, O, and Si. Hair fibers 4 (Topik™) and 5 (Nanogen™) were similar. Sample 4 derived from a keratin organic fiber and sample 5 from pure, positively charged keratin. In both cases, SEM revealed microfibers covered by a fine squamous. The X-ray microanalysis in both cases revealed a high presence of S. Conclusion: There was no discrepancy among the cosmetic results of the five samples, providing a successful esthetic effect in all of our patients despite the chemical differences found in the X-ray microanalysis.

Key words: Alopecia, cotton, keratin, reconstructive hair fibers, scanning electron microscopy, X-ray microanalysis
Reconstructive hair fibers, which can be sprinkled onto thinning hair and bald areas, are becoming a common method to hide hair loss. The fibers bond with existing hair by static electricity and instantly increase the density of the alopecic area in men and women [Figure 1]. They are a quick and easy solution that can be applied daily and are easily removed washing the hair or just using the hairdryer. As hair fibers do not chemically interact with other products applied on the hair or scalp, the physician is able to prescribe concomitant topical treatment if it is needed. Although those reconstruction fibers are, without doubt, the future of products to camouflage hair loss, there is a lack of objective information in the literature about their chemical structure and composition.

Hair fibers can be classified as synthetic or organic according to their composition. Organic fibers, mostly made of keratin or cotton, can be used in medical practice in patients with different types of alopecia or hypotrichosis, whereas synthetic ones, despite their lower prices, are not widely recommended.

In this article, we analyze and compare five different brands of organic hair fibers to have an objective overview of the products currently on the market.

**MATERIALS AND METHODS**

The composition of each hair fiber was carefully analyzed. A scanning electron microscope (SEM) JEOL FESEM J-7100 was used to obtain amplified images of samples to study their shape and structure. For more detail, X-ray microanalysis was performed with an EDS Oxford Inca to study the elemental composition of the studied samples.

To compare the effects of the application of hair fibers *in vivo*, we tested the five different samples of hair fibers in patients attending a Trichology Unit of a tertiary hospital. We included patients with androgenic alopecia, alopecia areata, telogen effluvium, and trichotillomania indistinctly, and we checked the immediate effect that reconstructive hair fibers had on patients’ appearance and its capacity to disguise their hair loss.

**RESULTS**

**Microanalysis of hair fibers**

**Hair fiber nº1 (Blum Secret™)**

Its main composition was cotton. As the cellulose content of cotton fiber is 90%, hair fiber nº1 was basically formed by a vegetable organic component.

Under SEM, this sample showed amounts of aggregates of fibers arranged in parallel. The X-ray microanalysis showed an organic polymer composed mainly by carbon (C) and oxygen (O), and lesser amounts of chlorine (Cl), sodium (Na), silicon (Si), sulfur (S), and aluminum (Al).

**Hair fiber nº2 (Viviscal™)**

The second sample analyzed was also derived from a vegetal source. In this case, the main component was a vegetable keratin extracted from corn, soybean, fig fruit and linseed.

SEM showed, as previously observed in the sample nº1, aggregates or clusters of fibers arranged also in parallel. In this case, X-ray microanalysis revealed that Si was one of the predominant elements and with C and O composed the vast majority of the organic polymer, whereas Cl, Na, S, and Al were found in small quantities.

**Hair fiber nº3 (Keratin™)**

The third sample was again a derivate of cotton; thus, it was an organic vegetable fiber predominantly composed of cellulose.

Surprisingly, SEM displayed two kinds of fiber shapes; on the one hand, there were aggregates of fibers arranged in parallel similar to the previous samples, and on the other hand, some smooth isolated fibers that resembled normal hair [Figure 2]. Because of this finding, the two kinds of fibers were analyzed separately. The X-ray analysis of fibers arranged in parallel showed that C, O, and Si composed the predominant organic polymer whereas Cl, Na, S, and Al were found in small amounts.

The X-ray analysis of smooth fibers showed a different composition, which consisted of an organic polymer mainly, composed by C and O, but also by a great quantity of S [Figure 3].

**Hair fiber nº4 (Toppik™)**

The fourth sample analyzed was composed by an animal derivate keratin organic fiber obtained from the sheep’s wool (Ovis aries). Thus, natural keratin was the main constituent.

In this case, SEM revealed microfibers covered by a fine squamous profile with a look and shape very similar to normal hair [Figure 4]. The X-ray microanalysis of the sample revealed a high presence of S, C, and O [Figure 5]. Chloride, Si, and Nitrogen (N) were poorly represented.
Figure 1: The reconstructive hair fibers: Their aspect under dermoscopy examination; easily adherence to the hair, reaching a high hair density on the alopecic areas.

Figure 2: Scanning electron microscopy of sample nº3: clusters of fibers arranged in parallel and others of smooth shape. The samples 1 and 2 show only a distribution in a parallel pattern.

Figure 3: X-ray microanalysis. The image above corresponds to the parallel pattern observed in samples 1, 2, and 3. The picture in the bottom corresponds to the smooth fibers intermingled with the other pattern in sample nº3. In both cases, these pictures correspond to an organic polymer composed mainly by C and O, plus Si in the arranged fibers in parallel pattern. The smooth fibers have a relevant content of S.

Figure 4: Scanning electron microscope images of samples nº4 (above) and nº5 (below). They are similar and very close to the normal structure of hair simulating even the cuticular shape.

Figure 5: X-ray microanalysis of sample nº4. The profile is very similar to normal hair with a high quantity of S. Sample nº5 revealed the same spectrum type.

Figure 6: Clinical appearance of an androgenic alopecia immediately after the application of reconstructive hair fibers.
Hair fiber nº5 (Nanogen™)

Finally, the fifth hair fiber was composed 100% by positively charged pure keratin. SEM revealed scaly microfibers virtually indistinguishable from normal hair [Figure 4]. The X-ray microanalysis of the sample revealed a high presence of S, C, and O. Silica and N were poorly represented and other oligoelements were absent.

Clinical aspects of hair fibers

We found no clinical differences between the immediate effects that hair fibers had on patients’ appearance, and the capability to camouflage hair loss in patients affected by androgenic alopecia [Figure 6], telogen effluvium, or trichotillomania. However, in alopecia areata, the five samples were unable to adhere to bald areas of the scalp.

The patients clearly manifested satisfaction using this camouflage system to disguise their different degrees of alopecia. None of the patients required changes to their medical treatment for alopecia, and neither secondary effects nor objections were reported when using hair fibers concomitantly.

DISCUSSION

Human hair is an appendage that grows from hair follicles. Hair keratin is a helical fibrous protein, made of long chains of amino acids, which makes up approximately 95% of hair composition. Amino acids, the building blocks of keratin, are made of lighter elements in the following proportions: C - 51%, O - 21%, N - 17%, hydrogen 6%, and S - 5%. Water, pigments, lipids, and some oligoelements compose the rest.[7,8] Bearing this in mind, it seems logical that the best fiber should be the one most resembling the normal composition of hair.

Thus, regarding our results and comparing them with normal hair, we lump together hair fibers 1, 2, and 3. They derive from a vegetal source and are formed by amounts of aggregates of fibers arranged in parallel. When analyzed with X-ray microanalysis, they were rich on C, O, and Si but had small amounts of S.

On the other hand, fibers 4 and 5, composed of animal derivate keratin, are virtually indistinguishable from normal hair both in shape and composition and consist of scaly microfibers with high presence of S.

However, despite the chemical differences found in the microanalysis, we did not observe discrepancies among the cosmetic results achieved. The capability to disguise hair loss was relevant in almost all cases of alopecia, and no differences were perceived on the immediate effects that all these hair fibers had on the patient’s appearance.

The fact that in alopecia areata fibers were unable to adhere to bald areas of the scalp can be explained by its mechanism of action based on physical laws. Hair fibers need to bond with existing hair by static electricity to instantly increase the density of the hypotrichotic area.

Hair fibers did not stain clothes and were easily removed by washing the hair or just properly applying the hairdryer. This fact was remarkable because it allowed us to apply the topical medical treatment daily.

Despite the fact that hair fibers are not useful in alopecia areata, they have a successful esthetic result in a wide range of different types of alopecia. Because of its easy and fast application, and the capability to hide hair loss, hair fibers may be a useful tool that will help to decrease the psychological impact of alopecia, such as anxiety or depression in our patients.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Grimalt R. Psychological aspects of hair disease. J Cosmet Dermatol 2005;4:142-7.
2. Chiang YZ, Bundy C, Griffiths CE, Paus R, Harries MJ. The role of beliefs: Lessons from a pilot study on illness perception, psychological distress and quality of life in patients with primary cicatricial alopecia. Br J Dermatol 2015;172:130-7.
3. Beckett ME. The need for a treatment: A patient's perspective. J Investig Dermatol Symp Proc 2015;17:42-3.
4. Rencz F, Brodzsky V, Galács I, Péntek M, Wikonkál N, Baji P, et al. Alopecia areata and health-related quality of life: A systematic review and meta-analysis. Br J Dermatol 2016;175:561-71.
5. Jankovic S, Peric J, Maksimovic N, Cirkovic A, Marinkovic J, Jankovic J, et al. Quality of life in patients with alopecia areata: A hospital-based cross-sectional study. J Eur Acad Dermatol Venereol 2016;30:840-6.
6. Katoulis AC, Christodoulou C, Liakou AI, Kouris A, Korholiakou P, Kaloudi E, et al. Quality of life and psychosocial impact of scarring and non-scarring alopecia in women. J Dtsch Dermatol Ges 2015;13:137-42.
7. Pollitt RJ, Stonier PD. Proteins of normal and trichothiodystrophic human hair. J Am Acad Dermatol 1988;18(4 Pt 1):745-6.