SEM Studies on Unmanageable Hair

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Summary. The manageability of the hair is dependent on the surface composition of the hair shaft. Exogenously caused damage leads to unmanageability by massive superficial defects in the hair cuticle. The symptoms of trichorrhhexis nodosa and trichoptilosis are present, and superficial horny scales are bent up and curve under in tunnel-like fashions. Appropriate hair care can improve these defects. Endogenous damage to the hair leading to unmanageability is characterized by spiral furrows along the shaft. It can not usually be improved by the use of care products.

The examples presented in the paper demonstrate that exogenous and endogenous causes of unmanageability are characterized by different alterations in the hair shaft.

The hair of the scalp has remained as a vestige in the phylogenetic regression of our coat of hair. From a functional point of view, it retains heat and offers protection from the damaging rays of sunlight. One need only bring to mind the damage often present on the skin of a bald man's head to note the damaging effect of sunlight. The care and maintenance of the hair of our heads is not only important because of its protective function, but also for aesthetic reasons. This aspect is likely the most important for many of us. The appearance of the hair on our heads significantly influences not only the way we look, but also our level of self-confidence and self-assurance.

The assessment of hair without the use of technical aids is quite difficult. As a rule, it is limited to an inexact measure of a "manageability" or the difficulty or ease with which the hair may be dressed. The compliability of the hair to dressing is dependent on the surface composition of the hair shaft. Hair which is difficult to dress exhibits marked alterations in the hair cuticle. Several examples presented in this paper demonstrate that endogenous and exogenous causes of unmanageability are characterized by different alterations in the hair shaft.

MATERIALS AND METHODS

Tufts of hair consisting of 10-15 individual hairs were epilated from the nape of the neck just above the hairline. The proximal portion of the shaft above the hair root was examined in each case. If one assumes a typical anagen/catagen/telogen ration of 10:0.5:2, it follows that predominantly anagen and telogen phase hairs were examined. Care was taken that the tufts of examined hair were consistently taken from areas which had been covered by longer hairs, because they were better protected from environmental influences than the outer layers of hair.

RESULTS

Normal surface of the hair

Healthy shafts of hair with normally structured cuticles exhibit individual variations. Fine hair appears rounded in cross-section. The scales of the cuticle are spread far apart so that individual scales are exposed over a large area on the surface of the hair (Fig. 1). In contrast thick hair is oval in cross-section. The scales of the cuticle are more densely packed, one behind the next, and therefore form several overlapping layers. In contrast to fine hair, thick hair shows just the narrow edges of the scales (Fig. 2).

The edges of the scales lie close together, densely packed on the surface of normal healthy hair. The shape of the surface scales of the cuticle is partly responsible for the manageability of the hair. Because of their location, these scales are directly exposed to exogenous influences. It is, therefore, not surprising that hair care products and the use of cosmetic substances are of particular importance for the healthy condition of the scales.

Fig. 1. Healthy shafts of hair. Light blonde "fine" hair from a woman of advanced age. Scales of the cuticle are spread far apart; their edges are coarse-indent and lie close on the surface of the hair. $\times 2,500$

Damage due to exogenous influences

Figure 3 depicts a hair which has become virtually impossible to comb as a result of so-called "normal hair care". This is a hair which was dyed two weeks prior to sampling and which has also been treated to a permanent wave six months previously, being a fine hair from a woman of advanced age. Some of the superficial horny scales are bent up over a broad area or, at points, curve under in a tunnel-like fashion. Longitudinal and even occasional diagonal cracks can be found along the hair shaft (Fig. 4). The broken ends are split (Fig. 5). The typical symptoms of trichorrhexis nodosa and trichoptilosis are present.

This type of exogenously caused damage was somewhat less prominent in thicker hair. Nonetheless, here also, this damage can lead to tangled hair after washing, sometimes to the point of complete unmanageability. Packs and rinses following shampooing can improve this situation.

The influence of appropriate hair care on this damaged hair is depicted in Figure 6. The manageability of the hair is improved through removal of the

curved scales and due to the fact that the edges of the scales are stuck to the surface of the hair.

Exogenous damage leads to unmanageability by causing massive superficial defects.

Endogenous damage

Trichoptilosis can also be an endogenous cause. Split ends, longitudinal and crosswise cracks in the shaft of the hair have been described for particular diseases, e.g., cachexia, long term fever, or diseases of the lung. However, the endogenously caused "syndrome of unmanageable hair" comprises changes in the hair shaft which are not observed in hair damaged by exogenous influences. In this syndrome, variations in caliber arise along the shaft of the hair. These are caused by furrows which run up the hair shaft in a spiral fashion (Fig. 7). The course of the furrows is manifold. They may generally run in a steep spiral with more gently sloping rounds in between. In this way, thin and thick regions alternate along the shaft of the hair (Fig. 8). Short, narrow dents without a spiral course may also be found from

Fig. 2. Healthy hair from a woman of advanced age. Dark blonde "thick" hair. $\times 2,500$

time to time (Fig. 9). Two furrows may run parallel to one another (Fig. 10). The cross-section of the hair is then triangular. If but one furrow is present in the shaft, the cross-section is kidney shaped. These hairs are called *pili torti*; they are always fine hairs with an extremely thin cuticle. The cuticle is frequently missing over a wide area so that the underlying cortex is directly exposed.

Unmanageability here is caused by the spiral furrows along the shaft of the hair and can not usually be improved by the use of hair care products.

DISCUSSION

Exogenous damage to the hair shaft leading to unmanageability is characterized by defects in the cuticle. The scales of the cuticle curve up at the free edges, thus exposing their undersurface to attack by aggressive substances. Hair care products which are inappropriate for the hair type as well as cosmetic substances used in the course of hair dressing procedures, as in dyeing or the application of a permanent wave, must be viewed as the primary aggressive

substances in question.

It is well known that a permanent wave causes extensive changes in the structure of the keratin of the hair. Hair dyes, and also hair care products such as shampoo or substances used to prevent dandruff, contain metal complexes which may significantly alter the mineral content of the hair and, therefore, the biochemical composition of the hair structure.

Thin hair reacts more sensitively to environmental influences than thicker hair. The cause of this lies in the structure of the cuticle. The cuticle is not only thinner in fine hairs, but the individual scales are also more exposed to environmental influences due to their broader free edges. Thin hair are viewed as an expression of the "economizing function of the hair matrix" (KRAUSE and CHUTSCH, 1987). Consuming diseases or diets can lead to the emergence of thin hair shafts due to this "economizing function".

Trichoptilosis, i.e., the appearance of split ends and crosswise and longitudinal cracks in the hair shaft, does not necessarily lead to unmanageability of the hair. If this finding occurs in conjunction with changes in the surface cuticle scales, however, the problem of unmanageability may occur much more

Fig. 3. Unmanageable hair, exogenous damage. Fine hair from a woman of advanced age, impossible to comb as a result of dyeing and permanent wave. The edges of the scales are bent up. $\times 600$

Fig. 4. Unmanageable hair, exogenous damage. Longitudinal (*arrow*) and diagonal (*arrowhead*) cracks; half of the shaft is broken off ($\star$) $\times 1,350$

Fig. 5. Unmanageable hair, exogenous damage. Trichoptilosis: several longitudinal and crosswise cracks. $\times 770$

Fig. 6. Unmanageable hair, after appropriate hair care; compare this hair with Fig. 3. Curved scales are removed, sometimes to the cortex of the hair. The edges of the scales are stuck to the surface more than before hair treatment. $\times 600$

rapidly. The isolated occurrence of trichoptilosis may not always be assumed to be caused by exogenous damage to the hair. This symptom may also be observed in conjunction with some diseases (KRAUSE and CHUTSCH, 1987).

Pili torti, i.e., furrowed or spiral hairs, are always indicative of endogenous damage. The cause here can be traced to a genetically determined defect in the ectoderm which is probably inherited in an autosomal dominant pattern. This hair has been described in the literature as "spun-glass hair" (BRAUN-FALCO et al., 1984). It can be neither combed nor brushed from the

time of birth onward. The individual hairs stand in all directions on the head. They are dry and finely crinkled. Pili torti are thin and usually light blonde. Lighter hair generally has lower concentrations of copper, manganese, lead, thallium and other trace elements than does darker hair. This has been explained by the low melanin content of lighter hair, as this pigment exhibits an especial affinity for certain metals (KRAUSE and CHUTSCH, 1987). Light blonde furrow and spiral hairs can, therefore, be viewed as indicators of a condition of deficiency in medical diagnosis.

Fig. 7. Unmanageable hair, endogenous damage. Pili torti. *arrow* furrows of a spiral hair. $\times 2,000$. **Inset:** Pili torti of different calibre. The edges of the scales are smooth and stuck to the surface of the hair. $\times 1,600$

Fig. 8. Unmanageable hair, pilus tortus. *Arrow* furrow induces variation in caliber along the shaft. $\times 350$

Fig. 9. Pilus tortus with a short, narrow dent. $\times 650$

Fig. 10. Pilus tortus with two furrows along the shaft of the hair. $\times 200$

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