Recent Findings with Computerized Methods for Scalp Hair Growth Measurements

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Sensitive tools have been developed in order to monitor hair loss and treatment responses. Recently the TrichoScan was presented (by RH) as such a method which combines epiluminescence microscopy (ELM) with automatic digital image analysis. Herewith new TrichoScan data obtained from 10 women and 21 men with androgenetic hair loss after 6 mo of treatment with 5%-minoxidil are presented. Even in this small cohort of patients, we noticed a significant increase of hair density, cumulative hair thickness and terminal hair counts. Alternative methods were developed during a human alopecia investigation and research technology (HAIR Technology®) programme at Skinterface. This involves contrast-enhancement, image acquisition, and processing by qualified technicians followed by computer-assisted image analysis. The specific identification of exogen hair, further adds to this very refined non-invasive investigative method for hair follicle function investigation. Regional variations of hair growth dynamics do exist in the human scalp such as in female patients complaining of hair loss, scalp hair density and growth on top of the head differs significantly from the occipital site. Finally, from transversal studies and from detailed monitoring of subsequent hair cycles during longitudinal studies, data were obtained that support the fact that shortening of hair cycle, slowing down of growth rates and thinning of hair shafts are heralding hair miniaturisation. In the workshop the TrichoScan, the method of Canfield and Skinterface have been shown.

Key words: computer-assisted hair analysis/hair/male and female alopecia/treatment/TrichoScan

Figure 1
Hair densities after treatment with minoxidil. TrichoScan: hair counts and cumulative hair thickness were analyzed for 6 mo in 10 women and 21 men with AGA treated with 5% minoxidil. In both sexes, at the vertex and in frontal balding in men, an statistically significant increase of hair density has been observed.

areas. In order to analyze the number of follicular units/cm² we defined the maximal distance of individual hairs, which belong to one follicular unit. With this mathematical approximation we can reveal follicular units, their density and the number of follicular units containing one, two, three or more hairs (Fig 2). In the future this tool may help surgeons to plan a hair transplantation better, in order avoid overtreatment and to preserve as much as donor area as possible.

Human Alopecia Investigation and Research Technology (H.A.I.R. Technology) at Skinterface

Alternative methods have been used at Skinterface (Van Neste et al., 1989) that are applicable to a wide range of clinical conditions. In short, after image acquisition (Van Neste et al., 1992) and processing by qualified technicians, computer-assisted image analysis generates refined data on disturbed hair growth dynamics in various genetic hair disorders (such as trichorhinophalangeal syndrome, Sauberard’s triangular alopecia, monilethrix (Van Neste et al., 2003)) including male and female pattern hair loss. Finally, hair loss increases with aging and hair depigmentation during aging alters hair growth dynamics (Van Neste, 2004; Van Neste and Tobin, 2004).

In a recent paper on female hair loss (Van Neste, in press a), hair growth measurements were collected in 92 female subjects complaining about hair loss. Clinically, they were classified as having a patterned hair loss according to Ludwig (L; n = 50), diffuse hair loss (D; n = 13) or no visible hair loss but complaining of hair shedding (N; n = 29). Two scalp sites on the top of the head and one occipital site were investigated with the contrast enhanced phototrichogram analysis (CE-PTG) (Fig 3).

In female scalp, we confirm that the top of the head shows usually a higher hair density than occipital sites. This physiological observation has also been found in male scalp.

Interestingly, in affected patients (Ludwig pattern (L) and diffuse hair loss (D)) the relative increase of hair counts after contrast enhancement (CE) was much higher (range 22.4%–28.3%) as compared to apparently unaffected females (N; range 8.2%–9.7%). This increase in hair counts was only due in part to the presence of less pigmented thinning hair (thickness less than 40 μm). Such thin hairs were found in statistically significantly higher proportions in younger patients with mildly severe (grade I) patterned alopecia (Ludwig: L).

More recently, along with the identification of the exogen stage of the hair cycle in animal fur (Milner et al., 2002), technological developments at Skinterface have helped to clear the “scalp scene” from any other loosely attached elements such as exogen hair (application patent: Skinterface—PCT/EP02/06434; June 12, 2002). This most recent refinement was applied in a recent investigation of 88 other female patients (41 with and 47 without patterned hair loss and using exogen-free CE-PTG; unpublished data). Exogen identification added specific information on a largely unsuspected phenomenon that influences significantly hair counts. From these studies, we concluded that the presence or absence of patterning, the clinical severity of the pattern, the increasing age were all associated with significant regression of scalp hair (decreased hair counts, thinner hair and slower growth rates) in female patients.

Finally, based on these data we suggest a three-step mechanism leading to hair loss as well in female as in male subjects (Van Neste et al., 2003):

1. a shortening of the growth phase of the hair cycle with maintained thickness (more shedding);
2. an intermittent production of short thin hair, i.e., morphological evidence of miniaturization;
3. a period of very occasional or almost no hair production (dormant follicles or irreversible follicular atrophy).

Therefore, any successful treatment hair loss should stop or reverse the process of hair follicle miniaturization, increase the number of terminal hair follicles while reducing vellus hair counts (Whiting et al., 1999) or increasing the percentage of follicles in the growth phase (Van Neste et al., 2000) or improving other parameters that influence the productivity of hair such as growth rate or thickness of anagen hairs. Functional follow-up of distinct hair follicle units using

Table I. Six months treatment with 5% minoxidil increases hair density, cumulative hair thickness, and terminal hair counts in both female and male androgenetic alopecia

<table>
<thead>
<tr>
<th>Gender</th>
<th>Hair density (1 per cm²)</th>
<th>Cumulative hair thickness (mm)</th>
<th>Terminal hair count (1 per cm²)</th>
<th>Vellus hair count (1 per cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female, vertex</td>
<td>162.7 vs 192.6, p &lt; 0.0001</td>
<td>4.21 vs 5.00, p = 0.0177</td>
<td>158.5 vs 189.7, p = 0.0004</td>
<td>4.27 vs 2.92, p = 0.541</td>
</tr>
<tr>
<td>Female, frontal</td>
<td>196.9 vs 210.4, p = 0.0446</td>
<td>5.17 vs 5.73, p = 0.0465</td>
<td>189.5 vs 205.9, p = 0.316</td>
<td>7.39 vs 4.60, p = 0.266</td>
</tr>
<tr>
<td>Female, vertex</td>
<td>152 vs 184, p = 0.047</td>
<td>3.60 vs 4.48, p = 0.011</td>
<td>146 vs 172</td>
<td>6.5 vs 7.5</td>
</tr>
</tbody>
</table>
a refined and calibrated method is the only way to clearly document these phenomena (Van Neste, in press, b).

**Conclusions**

With the TrichoScan an entirely automatic software has been created for the analysis of the aforementioned parameters of hair growth. In rather small clinical trials we show that the TrichoScan is able to reveal the response to treatment with 5% minoxidil in AGA of both sexes. The TrichoScan images are taken either with a video or digital system for ELM. These devices produce high quality and reproducible digital images, because the images are always taken at the same distance of the lens to the skin surfaces. In the future, 5 Megapixel digital cameras might allow to analyze the images even better and with different light sources we will try develop the software, that in the near future a hair dye is no longer necessary. Furthermore we are now able to count the density follicular units, which might be a new tool for hair surgeons (Fig 2).
The refined analytic technology used at Skinterface is along the lines pointed out in previous EHRS meetings on hair measurement techniques (Sinclair et al., 2003; Van Neste et al., 2003). Recently published results point to the fact that a combination of a highly sensitive and precise analytical approach together with a global calibrated method (Van Neste et al., in press) seems advisable in the context of kinetic monitoring of hair growth and hair loss in the hair clinic in general and this is warmly recommended in the context of efficacy analysis of new (and recognized!) compounds in future clinical trials.

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