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Is TrichoScan a new diagnostic method for diffuse hair loss?

Hatice UCE ÖZKOL[1,*], Ömer ÇALKA[1], Necmettin AKDENİZ[2]
[1]Department of Dermatology, Faculty of Medicine, Yüzüncü Yıl University, Van, Turkey
[2]Department of Dermatology, Faculty of Medicine, Atatürk University, Erzurum, Turkey

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Aim: In this study, we investigated the sensitivity of TrichoScan, a computer-based phototrichogram, in the evaluation of diffuse hair loss in women and the relationship between iron deficiency anemia and hair loss.

Materials and methods: We recruited 100 female patients with diffuse hair loss. In all of the patients, a 1-cm^2 area of hair located in a temporoparietal region was shortened to 0.5 mm. The shaved scalp regions were stained with black dye. The subject then waited for 12 min. Subsequently, pictures of these regions were taken with a videodermoscope and analyzed with the TrichoScan software program.

Results: The ferritin levels were markedly low in these groups. The ratio of anagen was highest in the telogen effluvium (TE) mild group, followed by the TE severe group, and was lowest in the androgenetic alopecia (AGA) group ($P < 0.05$). The ratio of telogen was markedly higher in the AGA group, and the difference was statistically significant when compared with the other 2 groups ($P < 0.05$).

Conclusion: The hair analysis results with the TrichoScan software were satisfactory and the results were consistent with the clinical diagnosis. In particular, the use of TrichoScan was very successful in the differentiation between AGA and TE.

Key words: Hair growth measurement, computer, TrichoScan, telogen effluvium, ferritin

1. Introduction

Diffuse hair loss is acute or chronic generalized hair thinning (1). Telogen effluvium (TE) is the most common clinical form of diffuse hair loss. Several diagnostic methods are available for hair disease; however, there are no gold standard methods for the exact diagnosis of hair disorders (2). TrichoScan is a computer-based phototrichogram and its use has recently become more popular among dermatologists. This program is loaded onto a dermatoscope that can differentiate between vellus and terminal hair and calculates the ratio of telogen and anagen hair follicles. It can be used in the evaluation of hair loss and the diagnosis of hair disorders (3). One of the most common causes of hair loss is iron deficiency anemia (IDA). In several studies, the level of ferritin was found to be between 20 and 30 µg in patients with diffuse hair loss; it has been accepted that the ideal ferritin level should be at least 40 µg for healthy hair growth (4).

In this study, we investigated the sensitivity of TrichoScan when it was used in the evaluation of diffuse hair loss in the female population and the relationship between IDA and hair loss.

2. Materials and methods

We recruited 100 female subjects with diffuse hair loss who applied to our clinic. The age range was from 17 to 70 years of age. The Institutional Review Board approved the study protocol. Those patients with psoriasis, discoid lupus erythematosus, lichen planus, alopecia areata, diffuse alopecia areata, and cicatricial alopecia were excluded from the study.

A detailed history was obtained for each patient, including systemic diseases. Patients signed an informed consent form after the nature of the study had been fully explained to them. Blood samples from each patient were taken for the analysis of a complete blood count, ferritin level, and iron binding capacity. The patient's age, duration of hair loss, type of hair loss, history of medications including hormones, menstrual irregularities, and increased hair growth were recorded. Various criteria were used to make a clinical distinction between the different types of hair loss. These included hair volume, hair parting, hair density, the frontal hairline, and the frequency of vellus hair and telogen hair.

In all patients, a 1-cm^2 area of hair located in a temporoparietal region was shortened with a razor

* Correspondence: drhaticeuce@mynet.com

(Hairliner, Wella, Germany) to 0.5 mm. Pictures (with 20× magnification) were taken from the shaved area with a videodermoscope. A special alcohol solution was applied to the area before the pictures were taken.

The patients were called back after 3 days for a hair pull test (HPT), having been instructed not to take a shower during that time. The HPT is a diagnostic method that is routinely applied in hair loss. We formed 2 groups to investigate whether we would be able to determine the activity of the disease according to the HPT. The shaved scalp regions were stained with black dye (Goldwell Top Chic, Black, Darmstadt, Germany), and then the patient waited for 12 min. Subsequently, this area was cleaned with a special alcohol solution (Kodan Spray, Schülke & Mayr, Vienna, Austria), and pictures of these regions were taken with a videodermoscope. These pictures were analyzed with the TrichoScan software program.

The amount of hair/cm^2, the ratio of anagen to telogen hair follicles, the number of vellus and terminal hairs, and the ratio of vellus hair to terminal hair were calculated with TrichoScan using the automated phototrichogram method (Fotofinder DERMA, TeachScreen Software, Bad Birnbach, Germany). In addition, the amount of hair growth (0.3–2.1 mm) in 3 days was detected. The laboratory results were added to the data, as well.

A statistical analysis of the data was performed by factorial variant analysis (factorial ANOVA). Next, the Duncan multiple range test was used to compare the different groups. The Z test was used for the comparison of the HPT results. $P < 0.05$ was considered statistically significant. This statistical analysis was conducted with SPSS 13.

3. Results

The recruited patients were classified into 3 groups: 1) TE mild, 2) TE severe, and 3) androgenetic alopecia (AGA). The patients' age range was between 17 and 63 years old, the mean age being 27.6 years of age. The patients were separated into 2 groups according to their positive or negative HPT results. There was no significant difference in HPT results between the groups, and no remarkable difference in the laboratory results was detected between the groups. Statistical data of the patients are given in Table 1.

The TrichoScan results of the patients are summarized in Tables 2 and Table 3. There were statistically significant differences in the hair density results obtained by the TrichoScan program between the TE mild and TE severe groups ($P < 0.05$), but no significant differences between the TE severe and AGA groups.

The ratio of anagen was the highest in the TE mild group, followed by the TE severe group, and was lowest in the AGA group ($P < 0.05$). The ratio of telogen was markedly high in the AGA group, and the difference was statistically significant when compared with the other 2 groups ($P < 0.05$). The amount of hair/cm^2 was higher in the TE mild group ($P < 0.05$). The group with the most hair growth was the TE mild group, which was statistically significant when compared to the other 2 groups ($P < 0.05$).

In the AGA group, the ratio of anagen was statistically different between the HPT positive and the HPT negative groups. The ratio of anagen was higher in the HPT positive AGA group than the negative group ($P < 0.05$). The ratio of telogen was statistically different between the groups, as well. The telogen ratio was higher in the HPT negative group than the HPT positive group ($P < 0.05$). The average of the obtained data is summarized in Table 1. Anemia was not detected in the patients, but the level of ferritin was markedly low.

Table 1. Statistical data of the general descriptive features (N = 100).

	Mean	Min	Max
Age	27.60	17	63
Ferritin	24.31	1.89	136.00
HB	13.32	8	16
HCT	40.20	28	46
Iron	85.22	10	311
IBC	301.59	36	474
THN	182.50	78	363
Hair/cm^2	248.35	22	498
Anagen	59.74	14	80
Telogen	40.25	20	87
Vell/cm^2	30.68	7	69
Ter/cm^2	217.63	61	447
Vellus hair	22.35	5	51
Terminal hair	160.07	55	326
0.3 mm ghn/day	38.23	12.00	158.00
0.6 mm ghn/day	14.34	4.00	40,00
1.2 mm ghn/day	8.27	0.00	22.00
2.1 mm ghn/day	8.36	0.00	45.00

HB: Hemoglobin, HCT: hematocrit, IBC: iron binding capacity; THN: total hair number; Hair/cm^2: hairs per cm^2; Vell/cm^2: vellus hairs per cm^2; Ter/cm^2: terminal hairs per cm^2; ghn: growing hair number; Min: minimum; Max: maximum; N: subject number.

Table 2. Statistical data of HPT negative groups with TrichoScan.

	Counted hair, mean ± SD	Hair/cm^2, mean ± SD	Anagen %, mean ± SD	Telogen %, mean ± SD	Vellus/cm^2, mean ± SD	Terminal/cm^2, mean ± SD	1.2 mm ghn/3 days, mean ± SD	2.1 mm ghn /3 days, mean ± SD
TE Mild	214.08 ± 56.01^a	285.00 ± 94.16^a	61.19 ± 12.8^a	38.81 ± 12.82^b	36.09±14.96	257.28 ± 75.92^a	10.17 ± .47^a	12.63 ± 12.22^a
TE Severe	161.50 ± 30.89^b	221.69 ± 42.28^b	55.21 ± 14.41^b	44.79 ± 14.41^b	28.39 ± 11.97	193.26 ± 37.04^b	6.94 ± 3.97^{ab}	4.81 ± 7.57^{ab}
AGA	148.17 ± 56.79^b	203.37 ± 77.96^b	38.03 ± 22.00^c	61.97 ±22.00^a	23.60 ± 24.32	179.83 ± 81.4^b	3.67 ± .51^b	0.67 ± 1.15^b

SD: Standard deviation, ghn: growing hair number, TE: telogen effluvium, HPT: hair pull test; AGA: androgenetic alopecia; different lowercase letters in a column represent significantly different means.

Table 3. Statistical data of HPT positive groups with TrichoScan

	Counted hair, mean ± SD	Hair/cm^2, mean ± SD	Anagen %, mean ± SD	Telogen %, mean ± SD	Vellus/cm^2, mean ± SD	Terminal/cm^2, mean ± SD	1.2 mm ghn/3 days, mean ± SD	2.1 mm ghn /3 days, mean ± SD
TE Mild	186.32 ± 50.20^a	255.70 ± 68.97^a	65.66 ± 11.14	34.25 ± 11.08^a	31.81 ± 12.11	223.86 ± 62.16^a	9.37 ± 6.08^a	12.89 ± 14.58^a
TE Severe	183.08 ±.57^a	251.22 ± 63.87^a	59.93 ± 14.36	40.07 ± 14.36^b	28.67 ± 2.40	215.77 ± 69.88^a	7.80 ± 4.90^{ab}	5.93 ± 7.14^b
AGA	131.38 ± 35.15^b	180.35 ± 48.23^b	57.79 ± 11.78	42.23 ± 11.79^b	26.53 ± 11.00	153.84 ± 49.48^b	6.13 ± 2.90^b	3.88 ± 4.26^b

SD: Standard deviation, ghn: growing hair number, TE: telogen effluvium, HPT: hair pull test; AGA: androgenetic alopecia; different lowercase letters in a column represent significantly different means.

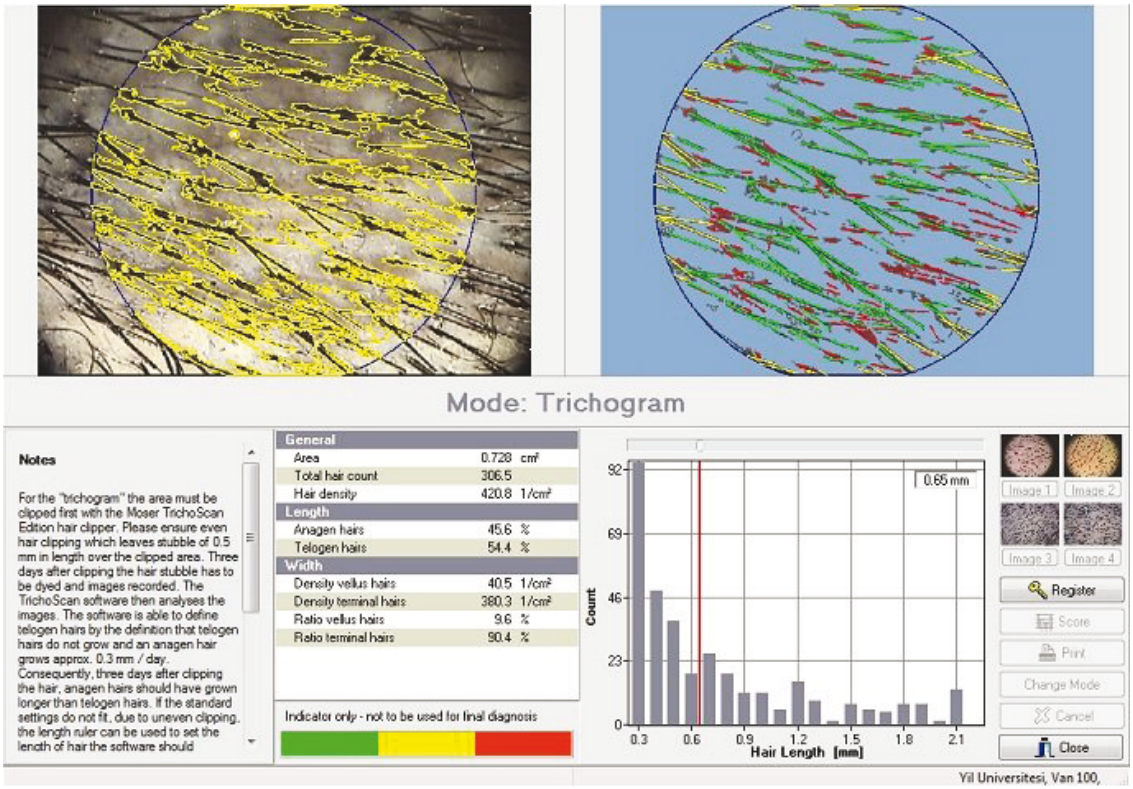

Figure 1. Example of TE mild.

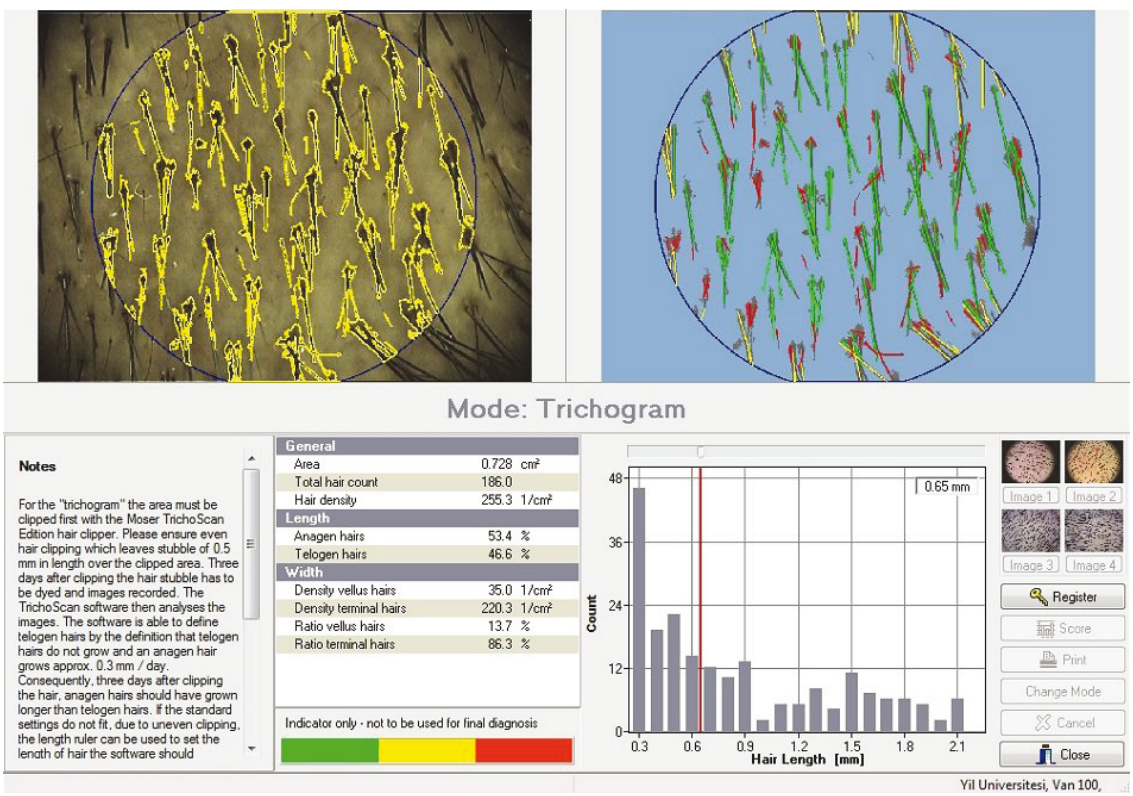

Figure 2. Example of TE severe.

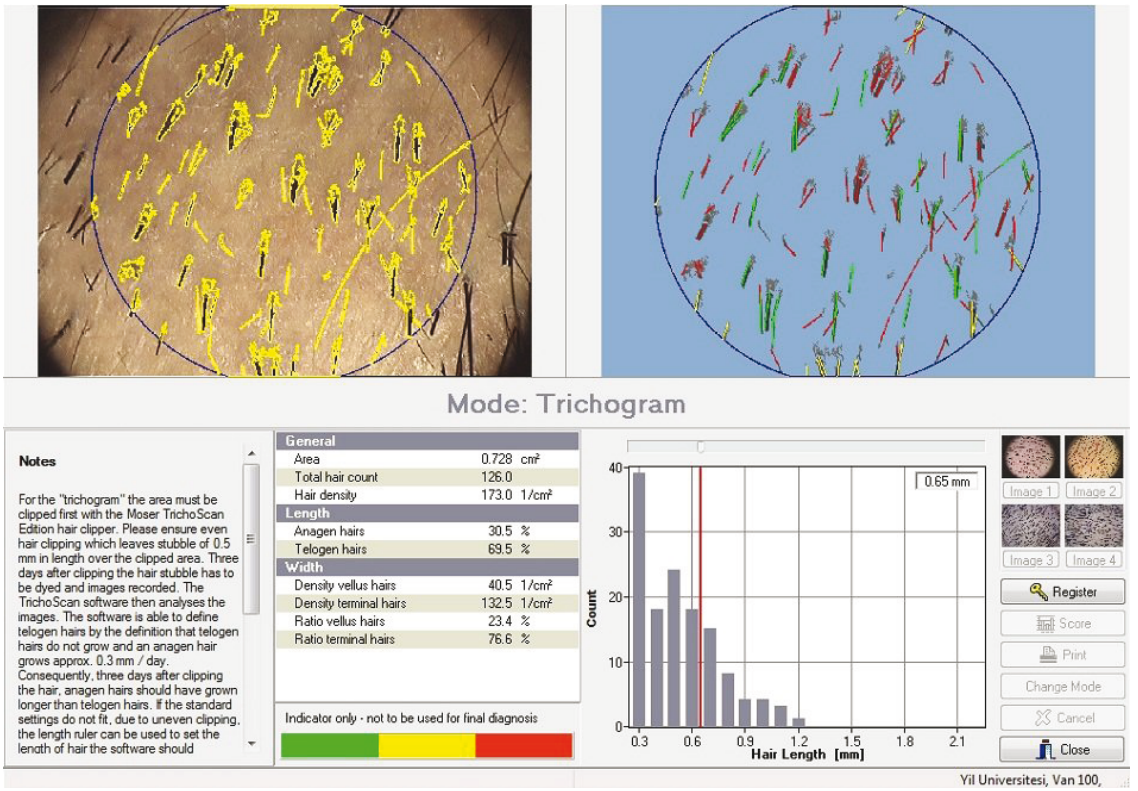

Figure 3. Example of AGA.

4. Discussion

An assessment of TE patients with TrichoScan, a new method recently developed for measuring hair growth, was evaluated for the first time in this study. TrichoScan is also one of the few noninvasive methods that combine epiluminescence microscopy with automatic digital image analysis (5).

The computer-based videodermoscope is used, in particular, for the early diagnosis of melanoma and the differential diagnosis of pigmentary lesions. Hair and hair follicles can also be examined by a videodermoscope with high resolution. The structure of the hair shaft, the differentiation of terminal hair and vellus hair, and the separation of different hair types, including monilethrix, pili annulati, and Netherton, can be performed with this method, as well (6). In our study, the amount of vellus hair was higher in the TE severe and AGA groups than the TE mild group. The highest amount of terminal hair was found in the TE mild group.

Hoffman investigated the hair density and the ratio of terminal hair to vellus hair with TrichoScan in AGA patients with and without finasteride treatment and in a control group. The hair density and the amount of terminal hair were significantly higher in the AGA patients with finasteride treatment than the patients without finasteride treatment (7). In our study, there were statistical differences in the hair density and the amount of terminal hair between the TE groups and the AGA group ($P < 0.05$).

The normal value of hair density shows variability in different studies. In a prior study, normal hair density value was determined to be 104–318 per cm^2 (mean: 211 ± 47.8 nonvellus hairs), calculated by a computer-based evaluation from macroscopic photos (8). In the study by Rushton et al., normal hair density was 181 hairs/cm^2 by phototrichogram and 237 hairs/cm^2 by unit area trichogram (9). In the study by De Villez et al., mean normal hair density was 211 per cm^2 (range: 104–318) for nonvellus hair (10). Birch et al. calculated normal hair density at 293 hairs/cm^2 by macro photographs (11). Lee et al. performed a 4-mm punch biopsy for detection of mean hair numbers in a Korean female and found 14.9/4 mm (118.63/cm^2) (12). In the study by Tajima et al., the normal hair density was 205.5 ± 50.5/cm^2 by phototrichogram (13). In our study, the normal hair density with the TrichoScan was 285.00 ± 94.16/cm^2 in the TE mild group, 221.69 ± 42.28/cm^2 in the TE severe group, and 203.37 ± 77.96/cm^2 in the AGA group. These findings did not show significant differences according to HPT results. The hair density value in the TE groups was consistent with the previous results. The lowest hair density was detected in the AGA group.

Vellus hair is a nonpigmented fine hair that lacks a medulla (14). Leroy et al. preferred to use the terminology "fine hair" instead of vellus hair, and described a hair with a diameter of less than 40 μm as a "fine hair" (15). In the study by Whiting et al., a follicle with a diameter of 0.03 mm or less was called a vellus or vellus-like hair (16). Rushton et al. defined vellus hair as a hair follicle of <40 μm in diameter and <30 mm in length (17). In our study, the amount of vellus hair, which was calculated by automated phototrichogram, was 28.6 7 ± 2.40/cm^2 in the TE severe group, 36.09 ± 14.96/cm^2 in the TE mild group, and 23.60 ± 24.32/cm^2 in the AGA group. There was no significant difference in the amount of vellus hair among the groups. However, a high amount of vellus hair was detected in AGA patients in previous studies. This disparity may be related to TrichoScan's sensitivity, as it does not detect hairs of less than 16 μm. Thus, a more sensitive software program should be developed.

Of the hair follicles in healthy skin, around 85%–90% are anagen, 13% telogen, and less than 1% catagen. Yürüker et al. diagnosed TE if follicles were 20% telogen by trichogram evaluation (14). In the study by Tajima et al., the patients' pictures were taken with a videodermoscope just after shaving the area of hair, and the percentage of anagen hair was 84% (13). However, we think that the calculation of the anagen/telogen ratio should wait until the hair has regrown. In the study by Sinclair et al., horizontal skin biopsy showed few catagen and telogen follicles, and the ratio of anagen to telogen was 14:1.2. This histological finding showed that the amount of telogen follicles is around 7000, and a mean of 70 telogen follicles fell off daily (18). In our study, the ratio of anagen to telogen was 1.57 in the TE mild group, 1.23 in the TE severe group, and 0.61 in the AGA group. There is a significant disparity between our results and the normal, healthy population. Our results might be meaningful because all our patients presented with hair loss and 90% were diagnosed with TE. There was a statistically significant difference in the ratio of anagen to telogen between the TE mild and AGA groups ($P < 0.005$). These findings did not show significant differences according to HPT results. Our ratio of anagen to telogen was markedly lower than normal individual biopsy results.

In the study by Sinclair et al. involving 305 patients, the differentiation between chronic TE and AGA was done by 3-punch biopsy. The ratio of terminal hair to vellus hair was >8:1 in the chronic TE patients and 4:1 in the AGA patients (18). In our study, the ratio of terminal hair to vellus hair was >7:1 in the TE patients and >5:1 in the AGA patients. Our results, obtained by a noninvasive method, were similar to the biopsy results.

In previous studies, trichogram and other clinical tests, including HPT, were more sensitive than phototrichogram in detecting telogen hair and the diagnosis of TE (14,19). In the study by Yürüker et al., the trichogram was more sensitive than the phototrichogram in detecting telogen hairs (14). In our study, the rate of telogen hair was detected at 38% with the TrichoScan in the TE patients, which was consistent with clinical findings.

The ideal ferritin level should be 70 μg/L in female patients with healthy hair (19). In the study by Kantor et al., the mean ferritin level was 23.3 μg/L in the TE group and 62.5 μg/L in the control group (20). In another study involving 200 patients with chronic TE, the ferritin level was less than 40 μg/L in 65% of the patients (21). The ferritin level should be >40 μg/L for healthy hair growth. Iron supplementation given to patients with low ferritin (even without IDA) significantly decreased hair loss (22). In our study, anemia was not detected in the patients; however, the level of ferritin was less than 40 μg/L in 72% of the patients. The mean ferritin level was 24.32 ± 2.31 μg/L. There were no differences in either the level of ferritin or IDA between the groups.

The most common disappointment the patients with TE voiced was their physician's understatements about their problems. For example, their physicians would say, "Your hair seems normal", or "There's no problem with your hair". However, patients usually have significant anxiety due to their hair loss. If a physician makes a decision about their condition without sufficient evaluation, most of the patients do not trust that decision and assume the physician is wasting their time and money (14,23). In our experience, the patients were usually satisfied and pleased with computer-based examinations.

There were some restrictive factors in this study. These factors were the small number of patients available for a healthy control group. We could not convince healthy individuals to try the TrichoScan application. Thus, a control group could not be created. In conclusion, computer-based details and careful examinations gave reassurance to the patients who were usually anxious due to hair loss. This reassurance is important for the patient's compliance with medical advice and treatment.

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