Quantitative Evaluation of Female Pattern Hair Loss in Chinese Women: A Preliminary Study

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BACKGROUND   The common grading systems for female pattern hair loss (FPHL), such as Ludwig and Savin scales, are subjective to visual inspection. To provide a more objective evaluation of baldness, the authors have developed a method to calculate baldness quantitatively through a computer-aided imaging system (CAIS).

OBJECTIVE   To investigate the use of CAIS on Chinese women with FPHL.

MATERIALS AND METHODS   Thirty-eight Chinese women with FPHL (Savin Scale I-2 to II-2) were recruited. A total of 215 photographs were taken. The central balding areas (CBAs) were calculated after exposure correction by CAIS for comparison with clinical staging.

RESULTS   The average CBA was 9,391.12 mm² in all patients, 3,828.84 mm² in Type I-2, 5,880.38 mm² in I-3, 8,267.44 mm² in I-4, 12,999.26 mm² in II-1, and 15,979.71 mm² in II-2. The values of CBA correlated with clinical staging using Savin scales. A 7.53% difference was found in the calculated CBA by exposure correction.

CONCLUSION   The CAIS allows physicians to evaluate the severity of baldness more accurately through quantitative calculation, rather than qualitative visual observation. The values of the CBA measured by the CAIS, used in conjunction with the present grading systems, may be more precise and efficient to evaluate the severity of FPHL.

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Female pattern hair loss (FPHL) is common among women who have hair loss.[1,2] Unlike male pattern hair loss (MPHL), FPHL is characterized by progressive thinning of hair in the central scalp with preserved frontal hair line.[3] Several clinical grading systems, including the Ludwig and Savin scales, are based on the area of baldness.[4,5] Because these conventional grading systems are mostly evaluated through qualitative visual inspection of the central balding area (CBA), variation may occur among different physicians and even in the same physician during the follow-up periods. Such problem can be solved by combining digital photography with computer-aided imaging system (CAIS), a powerful tool that can enhance communication between physicians and patients. It is beneficial to maintaining accurate records, for educating patients, and creating illustrations for publications and presentations for scientific use.[6]

For this reason, the authors conducted this study to quantitatively evaluate the CBA in Chinese women with FPHL using this CAIS.

Materials and Methods

Subjects

Thirty-eight healthy Chinese women aged 20 to 50 with FPHL were recruited from files of the authors' outpatient clinic. The clinical staging of baldness among subjects ranged from Savin Scale I-2 to II-2 (Table 1).

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TABLE 1. Staging and Area of Baldness

Savin Scale	I-2	I-3	I-4	II-1	II-2	Total
Patients	9	14	9	3	3	38
Photographs	47	78	55	16	19	215
CBA, mm^2	2,938.469–4,941.432	4,104.691–8,000	6,693.136–11,200	10,473.88–15,894.12	14,323.36–17,758.02	
MA, mm^2	3,828.837	5,880.382	8,267.435	12,999.26	15,979.71	

MA, mean area.

Methods

Standard photographs with a 45° frontal view at fixed distance were taken for each patient, with the hair parted centrally. Photographs were taken with a Nikon D700 (Nikon Corporation, Tokyo, Japan) with the default settings: aperture F-22, shutter speed 1/6,400 seconds, ISO 200, automatic white-balance, 300 dots-per-inch, and 3,008 × 2,000 resolution. The camera flashlight was fully charged before taking each photograph. A total of 215 photographs were taken. The CBAs of each photograph, both before and after exposure correction, were calculated with computer software developed by one of the authors (P.-K.H).[7]

With this computer software, areas of the scalp with sparse hair density were delineated on the image and distinguished from areas with normal hair density (Figure 1). The value of baldness was calculated using pixels from image. Based on this setting, each pixel of the image represents approximately 0.05 mm^2 of the actual scalp area. The details of complicated mathematical formula will not be described here.[7] Figure 1 shows the area of baldness calculated by the CAIS.

Statistical Analysis

To analyze the observed variance of each Savin scale, analysis of variance were performed, followed by the Tukey range test, which compared the bald areas in patients with a different Savin scale.

Result

Exposure correction resulted in 7.53% ($|CBA_{corrected} - CBA_{original}|/CBA_{corrected}$; n = 38) difference in the CBAs that were calculated. All data of calculated balding area are shown in Table 1. The average CBA was 9,391.12 mm^2 in all patients, 3,828.84 mm^2 in Type I-2, 5,880.38 mm^2 in I-3,

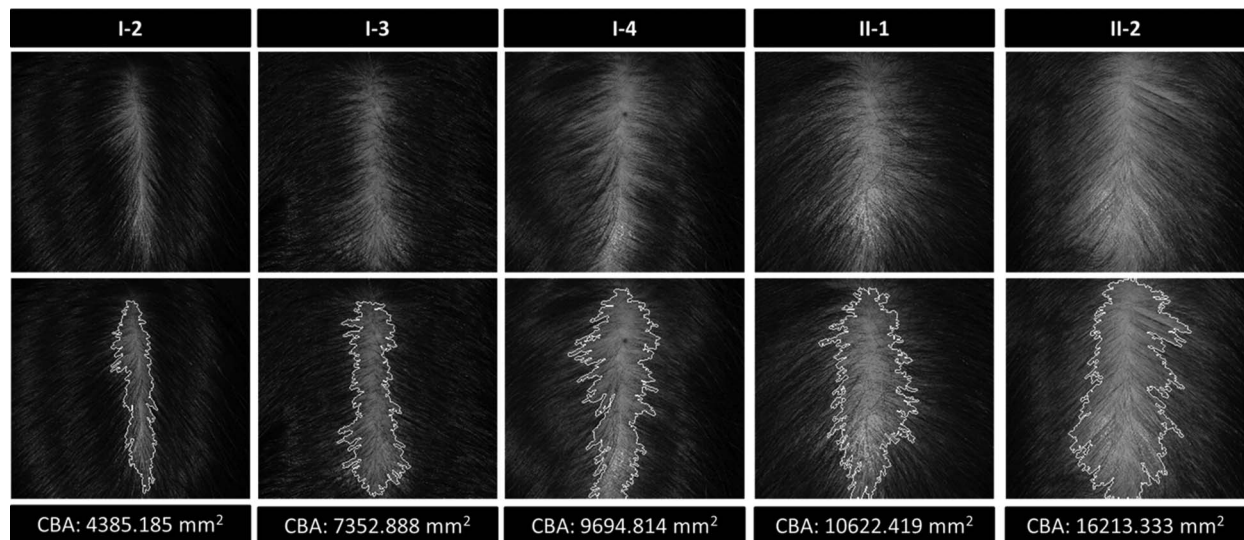| I-2	I-3	I-4	II-1	II-2
CBA: 4385.185 mm^2	CBA: 7352.888 mm^2	CBA: 9694.814 mm^2	CBA: 10622.419 mm^2	CBA: 16213.333 mm^2

Figure 1. Upper, corrected images of FPHL subjects with different Savin scales. Lower, CBA detected and calculated. The values are showed in bottom boxes.

8,267.44 mm² in I-4, 12,999.26 mm² in II-1, and 15,979.71 mm² in II-2. The values of CBA correlated with those of Savin scales, clinically. All variance between Savin scales were also statistically significant ($p < .05$).

Discussion

Most of the present imaging systems are used for disease diagnosis, i.e., detecting abnormal cells, tissue structure, or neogrowth. The imaging systems applied in dermatology, which were developed and used for early detection of melanoma, can be traced back to 2003.[8–10] Some imaging systems are used for the delineation of tumors and follow-up of treatment.[11] A good review article of computer-aided diagnostic support systems for skin cancer was published by Masood and Al-Jumaily in 2013.[12] With regards to pattern hair loss, trichoscopy, trichoscan, and tricho-photogram are also used for diagnosis through images of individual hair in terms of hair diameter, hair density, and characteristics of hair shaft. However, there are no existing imaging systems for the grading of FPHL based on quantitative measurement of the balding area.

Grading systems for FPHL, such as Ludwig and Savin scales, are widely used, clinically.[4,5] Although convenient, these grading systems may cause discrepancies between physicians, resulting in slight variations in communication. Recently, Lee proposed a new classification system called BASP, which describes more specific patterns of baldness in both MPHL and FPHL, with a combination of basic and specific types of baldness. The basic type represents the shape of anterior hair line which is divided into four types: L, M, C and U. The specific type represents the degree of thinning (hair density) of specific areas which is divided into two types: F and V. Each type is subdivided into 3 or 4 subtypes. The final type is determined by the combination of the basic and specific type such as M2V1.[13] Although the BASP classification provides a more accurate staging of pattern hair loss, it is still not commonly used, clinically, because of its relative complexity compared to other grading systems.

Because of the qualitative nature of grading systems for FPHL, the authors tried to find a more objective method to evaluate the severity of baldness. Before this study, there had been no existing image system used for staging and measurement of balding area in pattern hair loss. A CAIS was developed initially by the authors to measure the width of central baldness to present the extent of baldness, clinically.[7] From the initial study, the authors conducted the present study to calculate the actual area, rather than the width, of central baldness in Chinese women with FPHL to further examine the relationship between CBA and clinical grading of Savin scale. This system is the first attempt to use digital analysis on clinical photographs to calculate the balding area of the central scalp in patients with FPHL. The results of this preliminary study are promising.

From the results, the values of CBA correlated with Savin scales, clinically. All variance between Savin scales were statistically significant ($p < .05$). The average CBAs were 5,992.21 mm² and 14,489.49 mm² in Savin Scale I and II, which were also statistically significant ($p < .05$), and estimated to be equivalent to one fourth and half the area of the top scalp, respectively.[14] From the study, it has become possible to calculate the total CBA quantitatively in FPHL by the CAIS. Values of the total balding area, which were recorded by the CAIS, may further facilitate physicians to evaluate their patients with FPHL, more objectively in terms of clinical grading and the follow-up of treatment.

The CAIS may become a powerful tool that can assist the present grading systems such as Ludwig and Savin scales. However, some technical problems must be overcome before this system can be widely applied clinically. Before the measurement of balding area, exposure correction must be performed to prevent bias from different photographic conditions. In this study, there is a 7.53% difference in CBA. By placing an object of known dimension, such as a piece of metal or ruler, on the forehead mount that maintains the patient's position during global photography, the actual balding area (CBA) can be calculated by analyzing image distortion of the reference object in the photograph by extrapolation. Refining the procedures for the CAIS are currently under study in the authors' department. Athough the authors' study was based on

Chinese women with black hair, further studies need to be conducted to evaluate the suitability of the CAIS for patients of other race and hair color.

In conclusion, the study introduces an imaging system (CAIS) for clinical evaluation of FPHL. The authors hope this system can also be applied to other diseases of hair loss such as MPHL, alopecia areata, telogen effluvium, and scarring alopecia. It can also be used to evaluate other skin diseases, such as melasma and vitiligo, by capturing and measuring areas of the skin that are affected. The authors will also extend their study to other fields and races. The authors hope that this study could attract attention toward the use of imaging for evaluating hair loss and other skin disorders and lead to the development of more refined and reliable imaging systems in the dermatologic field.

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