

Physiological Profiles of Hair and Scalp Conditions in Korea Population: Survey, Hairological Expert-Diagnosis and New Diagnostic Device

Dong-Soon Park¹, Ji-Eun Koo¹, Soo-Yean Oh² and Hwa-Jung Choi^{2*}

¹Bundang Seoul National University Hospital Health Care Innovation Park 172, Dolma-ro, Bundang-gu, Seongnam-si, Gyeonggi-do 13605, Aram Huvis Co., Ltd., South Korea

²Department of Beauty Art, 142 Bansong Beltway (Bansong-dong), Busan 48015, Youngsan University, South Korea

*Corresponding author

Hwa-Jung Choi, Department of Beauty Art, 142 Bansong Beltway (Bansong-dong), Busan 48015, Youngsan University, South Korea

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Abstract

Many devices have been widely used to diagnose various skin and scalp disorders. However, existing devices may show few results of measurement contents or inaccuracy of results or inconvenience of use. In this study, two hundreds and forty Korea participants from whole South Korea were enrolled, conducted survey by self-questionnaire, diagnosed scalp type by hairological expert and diagnosed systemically hair and scalp conditions by APM PRO200 device. As the results, women is 70.7% and <20 ages were 99 (41.3%). The most subjects treated with shampoo 1 time per day (65.4%) and didn't have the dyeing (80.0%). The most frequent was A scalp type (41.7%) in hairological expert-diagnosis. The subjects of 46.3% had mild damage of hair cuticle, good exposure of sclap's vessel (87.1%), good hair density (78.3%), hair loss status of W type (68.3%), sensitive hair pore status (26.3%), good hair thickness (91.7%), bad corneous of scalp (47.5%) and scalp status (22.9%) status in diagnosis by APM PRO200 device. In anaysis of relationship between self-questionnaire and physiological profiles of hair and scalp conditions diagnosed by APM PRO200 device, exposure of scalp's vessel, hair loss status and hair pore status showed significant difference by sex and cuticle status, hair density, hair pore status, corneous of scalp and scalp status showed significant difference by age. Therefore, the diagnosis of hair and scalp conditions can be really facilitated by the APM PRO200 device.

Keywords: Diagnosis; Hair; Scalp, APM PRO200

Introuction

Hair is a unique characteristic possessed on all mammals [1]. In humans hair is a unique feature, but main functions of hair are in protection of the humans skin from mechanical injury and to facilitate homeothermy; eyelashes, for example, block somethings entering the eyes, while scalp hair blocks sunlight and physical damage to the circumference of head [2, 3]. Hair also has a sensory function, improving the perception of the skin for something stimuli, and subserves sexual roles and social communication, considering the psychological impact on life-quality showed in hair disorders such as hair loss [4]. In particular, a significantly higher superiority of personality disorders in peoples with androgenetic alopecia regarding the superiority of diagnoses on hair loss in the most population have been reported [5].

The appearance of an individual's hair is said to be reflective of internal health. Navigating the various diagnosis of trichodystrophies can be very complex; this contribution offers a question-by-question guide to making the correct diagnosis in subjects [6]. The hair of patients that the hair is not growing is fragile and breaks easily, or their hair volume is diminished and balding [7]. Patients with

monilethrix frequently are born with normal hair, but their hair is changed in the first few months with short and fragile hair [8]. Trichorrhhexis invaginata usually shows in infancy but may show initially in the eyebrows [9]. Loose anagen syndrome classically shows in a two-year-old people with blonde hair but can present in subjects with other hair colors, and the hair can favorably be pulled from the scalp skin [10].

Human scalp exhibits unique characteristics such as the highest density in hair follicles (200 hair/cm²) and an important sebum production (casual level of 150 lg/cm²) related with a unique resident microorganisms [11]. The presence of numerous hairs makes scalp a hidden region for consumers or researchers. Apart from work on unique disorders such as alopeci, a study on normal human scalp is scarce because of a blind site for measurements with device [12].

Intrumental machines equipped with cameras with high-magnification lenses have been widely used to diagnose a patient's or customer's scalp [13]. In diagnosis of scalp or hair, most doctors or experts manually record the condition on the scalp and the process

is slow and inconveniences the patients or customers [14]. So far, many study related with hair or scalp in Korea have been focusing on hair loss. Furthermore, few device to diagnose and analyze precisely and systemically hair or scalp of Korean was developed. Therefore, a new system for tracking the diagnostic device for the scalp of patients or customer will be further need to seek a higher performance and conveniences in actual situations.

In this study, APM PRO200 device for diagnosis and analysis of hair and scalp conditions was developed at Aram Huvis Co., Ltd. To obtain presentative data of South Korea against hair and scalp conditions, two hundreds and forty Korea participants from whole South Korea were enrolled in the study. They conducted survey by self-questionnaire and diagnosed type of scalp, scalp and hair status by hairlogical expert. The subjects also were diagnosed and analyzed systemically hair and scalp conditions by APM PRO200 device. The relationship between self-questionnaire and physiological profiles of hair and scalp conditions diagnosed by APM PRO200 device were analyzed. The correlation between scalp type by hairlogical expert-diagnosis and scalp status diagnosed by APM PRO200 device analyzed by Person correlation coefficient.

Materials and Methods

Study Design

Experimental system to diagnose hair and scalp conditions showed at Fig. 1. A total of 240 Korean, aged all, were enrolled in this study. This study was performed at 7 universities with department of beauty science representing 7 provinces in South Korea from september 2020 to december 2020 (Fig. 2). The method of the study was explained to the volunteers, and then the written informed consent was obtained. Before diagnosis on hair and scalp conditions by APM PRO200 device, the survey against participants was conducted by self-questionnaire (Table 1). Type of scalp, scalp and hair status of them were diagnosed by hairlogical expert-diagnosis (Table 1).



Figure 1. Experimental system to diagnose hair and scalp conditions. Two hundreds and forty Korea participants from whole South Korea were conducted survey by self-questionnaire, diagnosed scalp type by hairlogical expert and diagnosed systemically hair and scalp conditions by APM PRO200 device

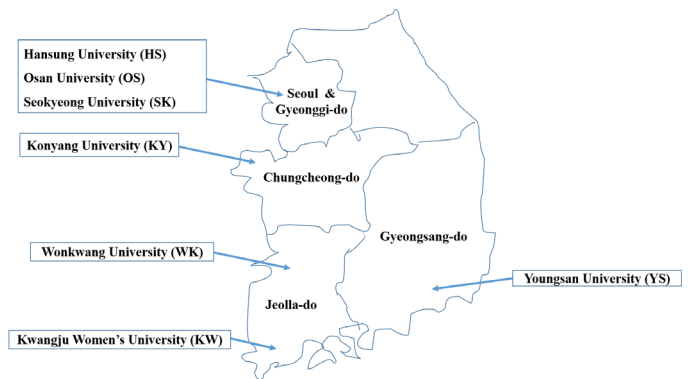


Figure 2. Representative 7 universities possessing department of beauty science in 7 provinces of South Korea. A total of 240 Korean in South Korea from september 2020 to december 2020 were enrolled in this study.

Table 1. Contents of self-questionnaire, hairlogical expert-diagnosis and diagnosis by APM PRO200 device

	Contents
Self-questionnaire	Dermographic characteristics (sex and age)
	Hospital diagnosis (scalp related disease, content of scalp diagnosis and product to improve scalp)
	Self-diagnosis of scalp (type of scalp, oily content, corneous, trouble/pimple, sensitivity, itch, fever, pain, consciousness of hair loss, heredity and stiff neck and shoulder)
	Life pattern (drug taking longtime, nutrients taking longtime, allergy, frequency and kinds of meal a day, diet, drinking, smoking, exercise and sleeping)
	Life diagnosis of women (menstrual cycle, menstrual quantity and experience of delivery)
	Management of hair and scalp (frequency of shampoo, cycle of permanent wave and cycle of dyeing)
	Used shampoo
Hairlogical expert	Type of scalp
	Scalp status (scalp status, scalp pore, scalp oily, scalp fever, scalp corneous, scalp corneous status, scalp trouble, scalp smell, scalp inflammation, dandruff and number of pore losing hair)
	Hair status (damage of hair, hair crumble and quantity of white hair)
APM PRO 200 device	Hair loss status, cuticle status, exposure of scalp's vessel, hair density, hair pore status, hair thickness, corneous of scalp and scalp status

For further analysis on scalp type diagnosed by hairological expert-diagnosis, we asked a blinded hairological expert to categorize 6 scalp types from A to F. The A and B types were classified into A-1, A-2 and A-3 for A type and B-1, B-2 and B-3 for B type.

The C type was classified into C-1 and C-2. The scalp taxonomy we used to classify scalp type by hairological expert in South Korea (Table 2).

Table 2. The scalp taxonomy classified by hairological expert in South Korea.

Scalp type		Scalp subtype	
Code	Characteristic	Code	Characteristic
A	Itch and oily	A-1	Prosperous oily
		A-2	Prosperous oily and inflammation
		A-3	Seborrheic
B	Dry and corneous	B-1	Dry
		B-2	Dry and scatter of corneous
		B-3	Atopy
C	Trouble (pimple)	C-1	Erytherma in hair follicles
		C-2	Folliculitis
D	Sensitivity		
F	Normal		
E	Hair loss		

The hair and scalp conditions by using of APM PRO200 device were diagnosed and analyzed (Fig. 3). The APM PRO200 was equipped with dual camera sensor of 1/4 inch color complimentary metal oxide semiconductor (CMOS, 5 mega pixel) × 1 camera sensor. The sensor pixel was total 5,038,848 pixels and effective pixel was 4,915,200 pixels. The image capture size was video graphics array (VGA) resolution (640 × 480). The device possessed nine measurement mode of customer face, hair loss status, scalp status, hair density, corneous of scalp, exposure of scalp's vessel, hair thickness, hair pore status and cuticle status. The magnification of camera differed from measurement contents (Table 3).

Table 3. Magnification of camera in APM PRO200

Model of camera	Magnification	Measurement content
Equipment within device	× 1	Customer face and hair loss status
202	× 60	Scalp status, Hair density, corneous of scalp and exposure of scalp's vessel
203	× 200	Hair thickness and hair pore status
204	× 500	Cuticle status

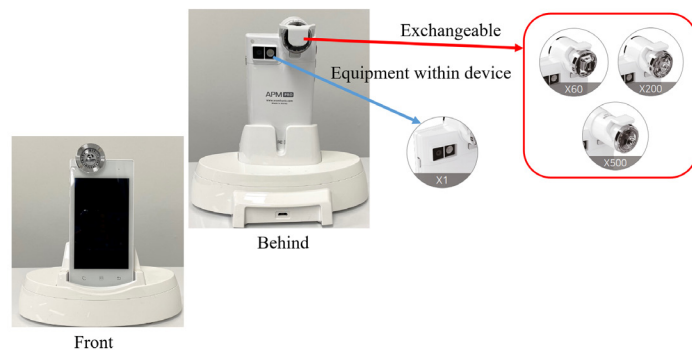


Figure 3. Photography of APM PRO200 device. The APM PRO200 was equipped with dual camera sensor of 1/4 inch color complimentary metal oxide semiconductor (CMOS, 5 mega pixel) × 1 camera sensor. The sensor pixel was total 5,038,848 pixels and effective pixel was 4,915,200 pixels. The image capture size was video graphics array (VGA) resolution (640 × 480). The device possessed nine measurement mode of customer face, hair loss status, scalp status, hair density, corneous of scalp, exposure of scalp's vessel, hair thickness, hair pore status and cuticle status.

The various physiological profiles in hair and scalp was evaluated by APM PRO200 device (Fig. 3). We were participated all subjects without exclusion criteria. The eight measurement contents were hair loss status, scalp status, hair density, corneous of scalp, exposure of scalp's vessel, hair thickness, hair pore status and cuticle status except for customer face (Table 3).

Measurements of Physiological Parameters

The participants were subjected to a one-time physiological properties' measurement. The measurement was conducted by a well-trained and experienced expert under standardized condition (temperature of 19°C–24°C and relative humidity of 60%–65%). All participants were in the measurement room for at least 15 minutes before the measurement for acclimatization. Each measurement were made by three readings. All measurements conducted at the same area.

Imaging System

Imaging of the hair and scalp was carried out during the measurements on the scalp surface. Scalp or hair images were acquired us-

ing an camera equipped with a high-magnification lens providing VGA 640 × 480 image capture size.

Analysis of Relationship between Self-Questionnaire and Physiological Profiles of Hair and Scalp Conditions Diagnosed by APM PRO200 Device

Self-questionnaire and diagnosis of scalp by hairlogical expert contained many contents. Thus, our team selected partial data and it was demographic characteristics (sex or ages), management of hair and scalp by subjects (frequency of shampoo or cycle of permanent wave or cycle of dyeing), type of scalp diagnosed by hairlogical expert and physiological profiles of hair and scalp conditions diagnosed by APM PRO200 device because our study is establishment of representative data against hair and scalp conditions by APM PRO200 device to overcome subjective diagnosis by expert.

The difference between demographic characteristics (sex or ages) and physiological profiles of hair and scalp conditions diagnosed by APM PRO200 device was analyzed by χ^2 -test.

Correlation Analysis Between Scalp Type by Hairlogical Expert-Diagnosis and Scalp Status Diagnosed by APM PRO200 Device

The scalp type by hairlogical expert-diagnosis and scalp status diagnosed by APM PRO200 device were analyzed by Person correlation coefficient.

Statistical Analysis

Statistical analysis was performed using SPSS for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA). The data were analyzed separately for man and women participants as the preliminary analysis revealed statistically significant difference in outcomes between genders. Categorical data was expressed as proportions. The difference or correlation between two categorical data was analyzed using chi-squared test. P value of less than 0.05 was considered to be statistically significant.

Results

Analysis of Self-Questionnaire

Only two categories (demographic characteristics and management of hair and scalp by subjects) among the many self-questionnaire was showed because of many data (Table 4). The 240 subjects had the following presentations: man, 72 (30.3%); women, 168 (70.7%). Less than 20 ages were 99 (41.3%), 30-40 ages were 90 (37.5%) and over 50 ages were 51 (21.3%). In analysis of management of hair and scalp, the most subjects treated with shampoo 1 time per day (157, 65.4%) and the other subjects (83, 34.6%) treated with shampoo another interval (Table 5). One hundred forty-eight (61.7%) subjects didn't have permanent wave, their 29.2% had permanent wave 1-3 times per year and the other subjects had permanent wave over 4 times per year. The subjects of 80% didn't have the dyeing and 25.0% subjects had dyeing over 7 times per year.

Table 4. Demographic characteristics

		N	%
Sex	Man	72	30.0
	Women	168	70.0
Age	<20	99	41.3
	30-40	90	37.5
	>50	51	21.3
Total		240	100.0

Table 5. Analysis on management of hair and scalp

		N	%
Frequency of shampoo	1 time per day	157	65.4
	Etc.	83	34.6
Cycle of permanent wave	Nothing	148	61.7
	1-3 times per year	70	29.2
	> 4 times per year	22	9.2
Cycle of dyeing	Nothing	80	33.3
	1-3 times per year	58	24.2
	4-6 times per year	42	17.5
	> 7 times per year	60	25.0
Total		240	100.0

Analysis of Scalp Type Diagnosed By Hairlogical Expert-Diagnosis

Of all the subjects, the most frequent was A scalp type, (100, 41.7%), most of which were A-1 scalp type, while A-3 scalp type were 8.8% (Table 6). Sixty-eight subjects (28.3%) were B scalp type and 16.3% among them was B-1 scalp type. C scalp type showed 2.1%. D, E and F scalp types were 6.7%, 11.3% and 10.0%, respectively.

Table 6. Scalp type diagnosed by hairlogical expert-diagnosis

Scalp type	Scalp subtype	N	%	N	%
A	A-1	44	18.3	100	41.7
	A-2	35	14.6		
	A-3	21	8.8		
B	B-1	39	16.3	68	28.3
	B-2	23	9.6		
	B-3	6	2.5		
C	C-1	1	0.4	5	2.1
	C-2	4	1.7		
D		16	6.7	16	6.7
E		27	11.3	27	11.3
F		24	10.0	24	10.0
Total		240	100.0	240	100.0

Physiological Profiles of Hair And Scalp Conditions Diagnosed by APM PRO200 Device

Of the 240 subjects who had access to the scalp and hair diagnosis in 2020, 111 subjects (46.3%) had mild damage of hair cuticle while 106 subjects (44.2%) had good condition of hair cuticle (Table 7). The exposure of scalp's vessel showed the following presentations: bad, 17 (7.1%); middle, 14 (5.8%); Good, 209 (87.1%). Thirty-one of subjects showed bad status against hair density (12.9%), 21 subjects (12.9%) showed mild hair density and the other (78.3%) showed good status on hair density. In hair loss status, most of them possessed W type (164, 68.3%) and 26.3% of them showed sensitive hair pore status and then the next showed oily hair pore status (52, 21.7%). The most of subjects showed good hair thickness (220, 91.7%). The corneous of scalp showing bad status was 114 subjects (47.5%) and the corneous of scalp showing good status was 106 subjects (44.2%). In diagnosis of scalp status, 22.9% of them was inflammatory status and the next was sensitive status (22.1%). Furthermore, the representative images captured and saved by APM PRO200 device showed in fig. 4.

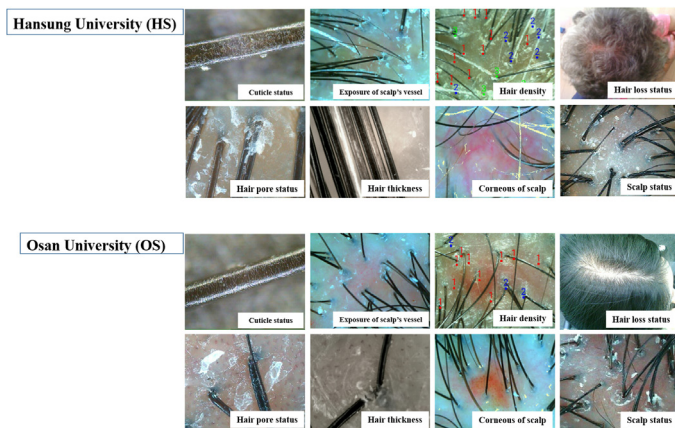


Figure 4. Representative images recorded by APM PRO200 device. Scalp or hair images were acquired using a camera equipped with a high-magnification lens providing VGA 640 × 480 image capture size.

Analysis of Relationship Between Self-Questionnaire and Physiological Profiles of Hair and Scalp Conditions Diagnosed by APM PRO200 Device

In analysis of relationship between physiological profiles of hair and scalp conditions diagnosed by APM PRO200 device and sex, exposure of scalp's vessel, hair loss status and hair pore status showed significant difference by sex ($p < .001$ for exposure of scalp's vessel and hair loss status, $p < .05$ for hair pore status

Table 7. Physiological profiles diagnosed by APM PRO200 device

Physiological profiles	Status	N	%
Cuticle status	Bad	23	9.6
	Mild	111	46.3
	Good	106	44.2
Exposure of scalp's vessel	Bad	17	7.1
	Mild	14	5.8
	Good	209	87.1
Hair density	Bad	31	12.9
	Mild	21	8.8
	Good	188	78.3
Hair loss status	M	63	26.3
	O	6	2.5
	C	7	2.9
	W	164	68.3
Hair pore status	Dandruff	10	4.2
	Dry	42	17.5
	Good	37	15.4
	Inflammation	32	13.3
	Oily	52	21.7
	Seborrhea	4	1.7
	Sensitivity	63	26.3
Hair thickness	Bad	1	0.4
	Mild	19	7.9
	Good	220	91.7
Corneous of scalp	Bad	114	47.5
	Mild	20	8.3
	Good	106	44.2
Scalp status	Dandruff	10	4.2
	Dry	32	13.3
	Good	39	16.3
	Hair loss	12	5.0
	Inflammation	55	22.9
	Oily	26	10.8
Total	Seborrhea	13	5.4
	Sensitivity	53	22.1
Total		240	100

and Table 8). The good status of exposure of scalp's vessel for man was 52 persons (72.2%) and it for women was 157 persons (93.5%) and then the women was higher than that of man (Table 8). Furthermore, M for most man among the hair loss status was 58 persons (80.6%) and W for most women was 163 persons (97.0%). Finally, most man showed sensitivity for hair pore status (41.7%) and most women exhibited oily for it (23.2%).

Table 8. Analysis of relationship between sex and physiological profiles

Physiological profiles		Sex		Total	χ^2 (p)
		Man	Women		
Cuticle status	Bad	4 (5.6%)	19 (11.3%)	23 (9.6%)	5.967 (.051)
	Mild	28 (38.9%)	83 (49.4%)	111 (46.3%)	
	Good	40 (55.6%)	66 (39.3%)	106 (44.2%)	
Exposure of scalp's vessel	Bad	10 (13.9%)	7 (4.2%)	17 (7.1%)	20.776*** (.000)
	Mild	10 (13.9%)	4 (2.4%)	14 (5.8%)	
	Good	52 (72.2%)	157 (93.5%)	209 (87.1%)	
Hair density	Bad	14 (19.4%)	17 (10.1%)	31 (12.9%)	4.243 (.120)
	Mild	7 (9.7%)	14 (8.3%)	21 (8.8%)	
	Good	51 (70.8%)	137 (81.5%)	188 (78.3%)	
Hair loss status	M	58 (80.6%)	5 (3.0%)	63 (26.3%)	213.347*** (.000)
	O	6 (8.3%)	0 (0.0%)	6 (2.5%)	
	C	7 (9.7%)	0 (0.0%)	7 (2.9%)	
	W	1 (1.4%)	163 (97.0%)	164 (68.3%)	
Hair pore status	Dandruff	2 (2.8%)	8 (4.8%)	10 (4.2%)	14.481* (.025)
	Dry	10 (13.9%)	32 (19.0%)	42 (17.5%)	
	Good	7 (9.7%)	30 (17.9%)	37 (15.4%)	
	Inflammation	8 (11.1%)	24 (14.3%)	32 (13.3%)	
	Oily	13 (18.1%)	39 (23.2%)	52 (21.7%)	
	Seborrhea	2 (2.8%)	2 (1.2%)	4 (1.7%)	
	Sensitivity	30(41.7%)	33 (19.6%)	63 (26.3%)	
Hair thickness	Bad	1 (1.4%)	0 (0.0%)	1 (.4%)	3.854 (.146)
	Mild	8 (11.1%)	11 (6.5%)	19 (7.9%)	
	Good	63 (87.5%)	157 (93.5%)	220 (91.7%)	
Corneous of scalp	Bad	39 (54.2%)	75 (44.6%)	114 (47.5%)	4.801 (.091)
	Mild	2 (2.8%)	18 (10.7%)	20 (8.3%)	
	Good	31 (43.1%)	75 (44.6%)	106 (44.2%)	
Scalp status	Dandruff	4 (5.6%)	6 (3.6%)	10 (4.2%)	6.411 (.493)
	Dry	7 (9.7%)	25 (14.9%)	32 (13.3%)	
	Good	8 (11.1%)	31 (18.5%)	39 (16.3%)	
	Hair loss	5 (6.9%)	7 (4.2%)	12 (5.0%)	
	Inflammation	16 (22.2%)	39 (23.2%)	55 (22.9%)	
	Oily	7 (9.7%)	19 (11.3%)	26 (10.8%)	
	Seborrhea	4 (5.6%)	9 (5.4%)	13 (5.4%)	
	Sensitivity	21 (29.2%)	32 (19.0%)	53 (22.1%)	
Total		72 (30.0%)	168 (70.0%)	240 (100.0%)	

*:p<.05, **:p<.01, ***:p<.001

Table 9 showed analysis of relationship between physiological profiles of hair and scalp conditions diagnosed by APM PRO200 device and age. The results showed significant difference between age and cuticle status, hair density, hair pore status, corneous of scalp and scalp status ($p<.05$, **: $p<.01$ and ***: $p<.001$). In relationship between age and cuticle status, 20 ages and 30-40 ages showed good cuticle status for 43.4% and 50.0%, respectively. The most of all ages showed good hair density with significant

difference. The >20 ages showed dry for hair pore status (25.3%), 30-40 ages was oily for it (31.1%) and <50 ages showed sensitive hair pore status (37.3%). In corneous of scalp, The most of all ages showed bad corneous of scalp (47.5%), the <20 ages was good corneous of scalp (57.6%) and 30-40 ages and >50 ages were bad corneous of scalp (46.7% and 76.5%, respectively). Inflammatory scalp status in <20 ages was 28.3% and scalp status of 30-40 ages and >50 ages were sensitivity (25.6% and 25.5%, respectively).

Table 9. Analysis of relationship between age and physiological profiles

Physiological profiles		Age			Total	χ^2 (p)
		<20	20-30	>50		
Cuticle status	Bad	16 (16.2%)	2 (2.2%)	5 (9.8%)	23 (9.6%)	12.779* (.012)
	Mild	40 (40.4%)	43 (47.8%)	28 (54.9%)	111 (46.3%)	
	Good	43 (43.4%)	45 (50.0%)	18 (35.3%)	106 (44.2%)	
Exposure of scalp's vessel	Bad	6 (6.1%)	8 (8.9%)	3 (5.9%)	17 (7.1%)	3.766 (.439)
	Mild	3 (3.0%)	6 (6.7%)	5 (9.8%)	14 (5.8%)	
	Good	90 (90.9%)	76 (84.4%)	43 (84.3%)	209 (87.1%)	
Hair density	Bad	6 (6.1%)	7 (7.8%)	18 (35.3%)	31 (12.9%)	35.218*** (.000)
	Mild	4 (4.0%)	12 (13.3%)	5 (9.8%)	21 (8.8%)	
	Good	89 (89.9%)	71 (78.9%)	28 (54.9%)	188 (78.3%)	
Hair loss status	M	25 (25.3%)	28 (31.1%)	10 (19.6%)	63 (26.3%)	
	O	1 (1.0%)	3 (3.3%)	2 (3.9%)	6 (2.5%)	
	C	0 (0.0%)	3 (3.3%)	4 (7.8%)	7 (2.9%)	
	W	73 (73.7%)	56 (62.2%)	35 (68.6%)	164 (68.3%)	
Hair pore status	Dandruff	3 (3.0%)	3 (3.3%)	4 (7.8%)	10 (4.2%)	27.009** (.008)
	Dry	25 (25.3%)	11 (12.2%)	6 (11.8%)	42 (17.5%)	
	Good	13 (13.1%)	11 (12.2%)	13 (25.5%)	37 (15.4%)	
	Inflammation	17 (17.2%)	11 (12.2%)	4 (7.8%)	32 (13.3%)	
	Oily	20 (20.2%)	28 (31.1%)	4 (7.8%)	52 (21.7%)	
	Seborrhea	1 (1.0%)	2 (2.2%)	1 (2.0%)	4 (1.7%)	
	Sensitivity	20 (20.2%)	24 (26.7%)	19 (37.3%)	63 (26.3%)	
Hair thickness	Bad	0 (0.0%)	0 (0.0%)	1 (2.0%)	1 (.4%)	4.598 (.331)
	Mild	6 (6.1%)	8 (8.9%)	5 (9.8%)	19 (7.9%)	
	Good	93 (93.9%)	82 (91.1%)	45 (88.2%)	220 (91.7%)	
Corneous of scalp	Bad	33 (33.3%)	42 (46.7%)	39 (76.5%)	114 (47.5%)	26.598*** (.000)
	Mild	9 (9.1%)	10 (11.1%)	1 (2.0%)	20 (8.3%)	
	Good	57 (57.6%)	38 (42.2%)	11 (21.6%)	106 (44.2%)	
Scalp status	Dandruff	4 (4.0%)	4 (4.4%)	2 (3.9%)	10 (4.2%)	32.919** (.003)
	Dry	17 (17.2%)	7 (7.8%)	8 (15.7%)	32 (13.3%)	
	Good	14 (14.1%)	13 (14.4%)	12 (23.5%)	39 (16.3%)	
	Hair loss	3 (3.0%)	1 (1.1%)	8 (15.7%)	12 (5.0%)	
	Inflammation	28 (28.3%)	23 (25.6%)	4 (7.8%)	55 (22.9%)	
	Oily	11 (11.1%)	13 (14.4%)	2 (3.9%)	26 (10.8%)	
	Seborrhea	5 (5.1%)	6 (6.7%)	2 (3.9%)	13 (5.4%)	
	Sensitivity	17 (17.2%)	23 (25.6%)	13 (25.5%)	53 (22.1%)	
Total		99 (41.3%)	90 (37.5%)	51 (21.2%)	240 (100.0%)	

*:p<.05, **:p<.01, ***:p<.001

Pearson Correlation Analysis Scalp Type by Hairological Expert-Diagnosis and Scalp Status Diagnosed by APM PRO200 Device

The scalp status (Dry and scatter of corneous, Dry, Normal, Hair loss, Prosperous oily and inflammation, Prosperous oily, Seborrheic and Sensitivity) among the 8 physiological profiles diagnosed by APM PRO200 device was consistent nearly with scalp type by

hairological expert-diagnosis (Dandruff, Dry, Good, Hair loss, Inflammation, Oily, Seborrhea and Sensitivity, Table 10). Therefore, the scalp type by hairological expert-diagnosis and scalp status diagnosed by APM PRO200 device compared by Pearson correlation analysis. In Table 10, the scalp type and scalp status showed low correlation ($r = 0.2348056$).

Table 10. Pearson correlation analysis of scalp type by hairological expert-diagnosis and scalp status diagnosed by APM PRO200 device

	Scalp type	Scalp status
Scalp type	1	
Scalp status	0.1348056	1

Therefore, scalp type diagnosed by hairological expert-diagnosis is standard index in South Korea. However, the index didn't show more various results than that of scalp diagnosed by APM PRO200 device. Furthermore, our system tracks the diagnostic area during the examination using images. The proposed device has broad analytic area, can detect the analytic region faster, is a conventional method for the user and can obtain objective data with images. Therefore, in future study, we plan to research methods to improve the accuracy and speed of our system by addition sensors and to apply artificial intelligence (AI).

Discussion

Hair is a unique character of mammals, where hair shafts possess a number of different functions such as collection of sensory information and protection against environmental changes and social communications [15]. As human hair is one of the physical characters which is easier to change in length, color or shape, people within any society has a unique idea of beauty [16]. Most people possess an estimated total number of 5 million hair follicles (HF), HF of 80,000–150,000 are located on the scalp [17]. The scalp is that part of the skin which extends from the eyebrows to the nape of the neck [18].

The chemical components of the hair or scalp skin shaft can be easily changed by environmental conditions, such as ultraviolet (UV) radiation, heat, humidity, and chemical agents [19]. Chemicals using in bleaching or waving break the disulfide bonds in the keratin of hair and also induce hair damage [20].

The office dermatologist or physicians may often be confronted with customers presenting a wide range of different hair and scalp disorders, ranging from rare congenital hair fiber abnormalities, pattern loss, chronic effluvium, or indeed simply the effects of chronic weathering [21]. Generally, hair and scalp disorders given hair's important role in determining self-image, social perception, and psychosocial functioning, the psychological impact of such conditions may be high. For that reason, hair and scalp disorders can prove distressing for both men and women.

The use of artificial intelligence device may be another method of broadening the use of dermatology or hairology expertise. A differential diagnosis is a ranked list of diagnoses that is used to plan treatments in the common setting of diagnostic ambiguity in dermatology, and can capture a more comprehensive assessment of a clinical case than a single diagnosis [22].

In article, a total of 240 Korean subjects enrolled from 7 universities with department of beauty science representing 7 provinces in South Korea from September 2020 to December 2020 conducted survey by self-questionnaire, diagnosis of scalp and hair status by hairological expert and APM PRO200 diagnostic device. Further-

more, a detailed scalp and hair inspection and diagnosis system, named APM PRO200, is manufactured for use in hair scalp diagnosis. The manufactured system is composed of a portable scalp and hair imaging camera with various magnification. In this study, man was 72 (30.3%) and women is 168 (70.7%). Less than 20 ages were 99 (41.3%), 30-40 ages were 90 (37.5%) and over 50 ages were 51 (21.3%). In analysis of management of hair and scalp, the most subjects treated with shampoo 1 time per day (65.4%), 148 (61.7%) subjects didn't have permanent wave and 80% of them didn't have the dyeing. In analysis of scalp type diagnosed by hairological expert-diagnosis, the most frequent was A scalp type (41.7%), 68 subjects (28.3%) were B scalp type and C scalp type showed 2.1%. D, E and F scalp types were 6.7%, 11.3% and 10.0%, respectively.

In physiological profiles of hair and scalp conditions diagnosed by APM PRO200 device, 111 subjects (46.3%) had mild damage of hair cuticle, the most of exposure of scalp's vessel was good (87.1%), 188 subjects (78.3%) showed good hair density, most of them possessed hair loss status of W type (68.3%). 26.3% of them showed sensitive hair pore status. The most of subjects also showed good hair thickness (91.7%) and the corneous of scalp showing bad status was 114 subjects (47.5%). In diagnosis of scalp status, 22.9% of them was inflammatory status and the next was sensitive status (22.1%). In analysis of relationship between self-questionnaire and physiological profiles of hair and scalp conditions diagnosed by APM PRO200 device, exposure of scalp's vessel, hair loss status and hair pore status showed significant difference by sex and cuticle status, hair density, hair pore status, corneous of scalp and scalp status showed significant difference by age. In Pearson correlation analysis between scalp type by hairological expert-diagnosis and scalp status diagnosed by APM PRO200 device, the scalp type and scalp status showed low correlation ($r = 0.2348056$).

Therefore, scalp type diagnosed by hairological expert-diagnosis is standard index in South Korea. However, the index didn't show more various results than that of scalp diagnosed by APM PRO200 device. Furthermore, our system tracks the diagnostic area during the examination using images. The proposed device has broad analytic area, can detect the analytic region faster, is a conventional method for the user and can obtain objective data with images. Therefore, in future study, we plan to research methods to improve the accuracy and speed of our system by addition sensors and to apply artificial intelligence (AI).

Conclusions

To obtain presentative and objective data of South Korea against hair and scalp conditions, 240 Korea participants from whole South Korea were enrolled in the study. They conducted survey by self-questionnaire and diagnosed scalp type by hairological expert and diagnosed and analyzed systemically hair and scalp conditions by APM PRO200 device. The proposed a new device can track the data used to diagnose scalp skin and hair. This system comprises changeable cameras for capturing images of the scalp or hair and a diagnostic device to capture the various region of head of the customer. In Pearson correlation analysis between scalp type by hairological expert-diagnosis and scalp status diagnosed by APM PRO200 device, several limits of hairological expert-diagnosis re-

vealed. Therefore, the future of hair and scalp diagnostic device will be the development of more efficient and accurate according to consumers' needs and concerns.

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Conflict of interest

The authors have declared no conflict of interest.

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