한국 여성의 연령에 따른 색소 침착 변화 연구

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아모레퍼시픽 R&I 센터
(2023년 4월 28일 접수, 2023년 6월 14일 수정, 2023년 6월 29일 채택)

The Study of Age-related Skin Pigmentation Changes in Korean Female

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(Received April 28, 2023; Revised June 14, 2023; Accepted June 29, 2023)

요 약: 얼굴의 피부 색소침착은 피부 노화의 시각적 특징 중 하나이므로, 화장품 및 미용 분야에서 피부 색소침착을 평가하는 것이 중요하다. 몇몇 그룹들은 피부 색소침착에 대한 이미지 분석 방법을 연구하고 개발했으며, 일부 그룹들은 얼굴 피부 색소침착이 연령에 따라 변화한다고 보고하였다. 그러나 정의된 크기에 따른 색소침착 수 및 크기의 변화를 보여주지 않았으며, 한국 여성의 색소침착에 관한 보고는 없었다. 이에 20 ~ 79 세 한국 여성 194 명 (48.97 ± 17.11 세)의 안면 디지털 사진을 large high-pass filter, median filter등을 이용하여 색소침착 수와 크기 그리고 강도를 분석하였다. 연령과 전체 색소 침착 수, 크기 및 강도 사이에는 유의한 상관관계 (pearson 상관계수 r = 0.688, r = 0.645, r = −0.563)가 있었으며, 세부 크기별 수와 강도간에도 유의한 상관관계를 나타냈다. 분산분석 결과에 따르면, 20 대와 70 대사이의 2 ~ 4 mm^{2}와 〉 20 mm^2 색소 침착 크기의 백분율에는 유의한 차이가 있었다. 즉, 노화와 함께 안면피부에 색소 침착이 늘어나며, 특히 한국 여성에서 큰 색소 침착의 증가가 두드러진 현상이다.

Abstract: Since facial skin pigmentation is one of the visual characteristics of skin aging, it is important to evaluate skin pigmentation in the cosmetics and aesthetic fields. Several groups have investigated and developed the image analysis methods for skin pigmentation and some of the groups reported the age-related changes of the number and size of facial pigmented spots. However, they didn't show the changes of the number and size of pigment spots by defined size, and there is no report for Korean female regarding pigmentation. A total of 194 Korean females aged 20 ~ 79 (48.97 ± 17.11 years) were analyzed for the number, size, and intensity of pigmented spots using various filters such as large high-pass filter and median filter in their digital facial images. There were significant correlations between age and total pigmented spot number (No.), size, and intensity (I) (pearson's correlation coefficient r = 0.688, r = 0.645, r = -0.563), and significant correlations were also observed between the number and intensity of pigmented spots of different sizes. According to the ANOVA results, there were significant differences in the percentage of spot size of 2 ~ 4 mm^2 and > 20 mm^2 between 20's and 70's. In other words, with aging, pigmentation increases in the facial skin, and the large increase in pigmentation is particularly noticeable in Korean women.

Keywords: *pigmented spot, image analysis, aging symptom*

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1. Introduction

The skin pigmentation spot could be clearly and relatively dark than own normal skin tone. Skin pigmentation have various types such as post-inflammatory hyperpigmentation (PIH), solar lentigines, melasma, freckle, nevus of Ota, and so on, and several groups have investigated and developed the digital image analysis methods or analysis of hyperspectral camera reflectance for skin pigmentation pigmented spot could be detected and determined by digital image analysis[1-7]. Recently, based on a large amount of data, artificial intelligence (AI) is used to determine pigmentation spot, and it is even being serviced online for commercial purposes.

Some of the groups reported age-related changes of facial skin color or pigmented spot number and size of Japanese female[3, 4] and other research group was reported the facial pigmentation severity and proposed hyperpigmentation types based on the patterns of facial pigmentary demarcation lines in Korean female[7]. However, they didn't show the changes of pigment spot number and size by defined size, and there is no report for Korean female in focusing this pigmentation classification by size. This investigation aimed to study and report changing of number and size of pigmentation spot and aging phenomenon on Korean female face.

2. Materials and Methods

2.1. Ethical Considerations

All volunteers gave written informed consent to participate in the study, and all experimental procedures were performed according to the ethical principles of the Declaration of Helsinki and, approved by institutional review board (IRB No. P1502-027).

2.2. Image Processing

A total of 194 Korean female (age: 20 ~ 79 y, 48.97 ± 17.11) who live in or near Seoul were enrolled for this study. After washing their faces, all volunteers were kept for at least 20 min in a study room (temperature 20 ~ 24 ℃ and R.H 40 ~ 60%). Digital facial images were taken by VISIA-CR
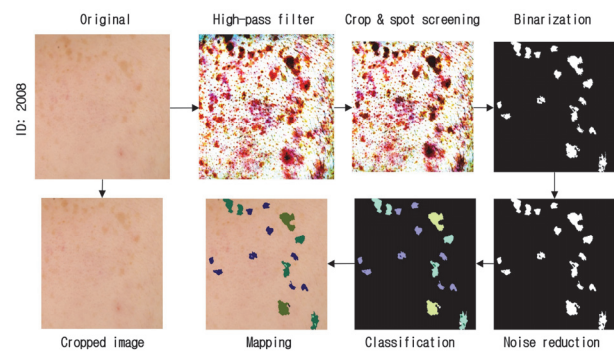
Figure 1. Summary of image processing.

(Canfield science, USA) and saved sRGB color system. The cross polarized images of the cheek areas with 1,200 × 1,200 pixels were cropped, and then applied various filters such as large high-pass filter (width & height 351, strength 30) for enhancing the pigmented spot and median filter (5 × 5 pixel, threshold percentage 20, passes 3) for noise reduction. Pigmented spots were screened base on size (> 2 mm^2), width (> 14 pixel), and intensity (I) (I < 100 a.u). Referring to the previous research[2,3], the detected spots were classified into 4 classes, each class being 2 ~ 4 mm^2, 4 ~ 10 mm^2, 10 ~ 20 mm^2, and > 20 mm^2. All image processing was performed by Image-Pro Premier 9.2 (Media Cybernetics, USA) and detected spots were analyzed the pigmented spots number (No.), size and I. Figure 1 shows the summary of the image processing procedure.

2.3. Data Analysis

If there were no pigmented spots in the class, the number and total size were considered as "0", and the intensity (tone values) were excluded from the analysis. Statistical analysis was performed using SPSS 23 software (IBM SPSS, USA) with a significance level of $p < 0.05$. Most data were expressed as mean ± SD (standard deviation). The correlation analysis and stepwise multiple regression analysis were performed with age and pigmented spot values, ANOVA (analysis of variance) was used to calculate the statistical difference of spot number, total size, intensity, and spot number, size percentage (%) among age groups(age decades), and the Scheffe's or Games-Howell test was used for *post hoc* analysis[8].
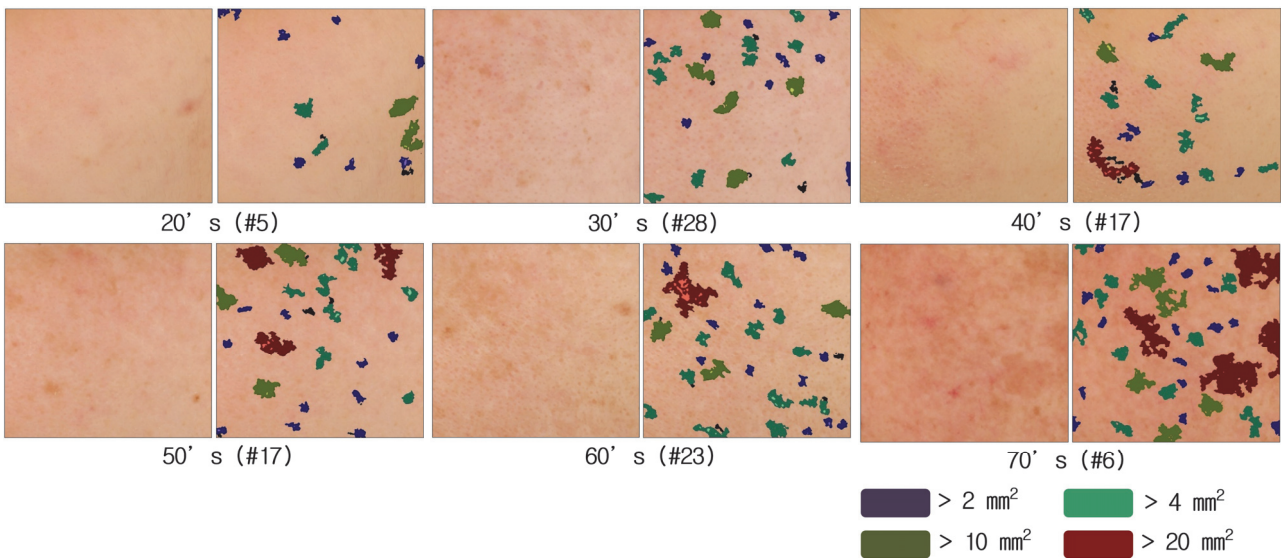
3. Results

The total number of pigmented spots, total pigmented spot size (mm^2), and spots intensity were significantly ($p < 0.001$) correlated with age (Pearson's r were 0.688, 0.645, and -0.563, respectively, Figure 2). The total number of pigmented spots and the total pigmented spots size increased with age, and the pigmented spots intensity was darker. The example results images of each age group (decade) were shown in Figure 3. According to the result of stepwise multiple
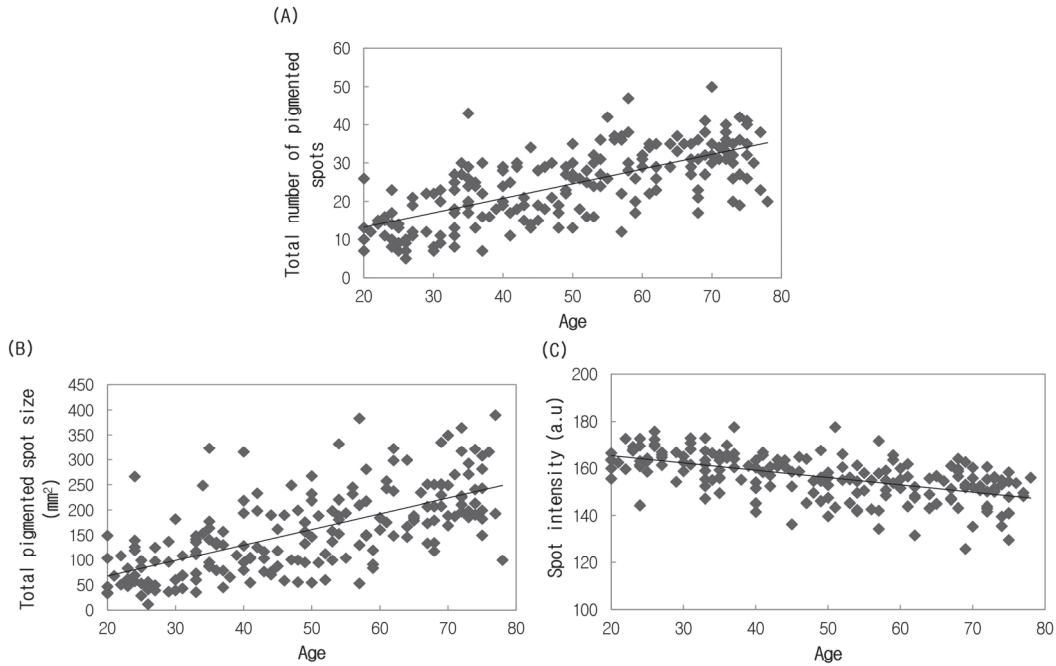
Figure 2. The scatter plots and regression lines between pigmented spots and age. total pigmented spot no., size, and spot intensity showed significantly correlation with age (A-C).

Figure 3. Example images of analyzed pigment spots of age groups. #No. means volunteer's sub ID of their age group.

Table 1. Results of Stepwise Multiple Regression Analysis of Age and Total Number of Pigmented spot, Spot Intensity. "adj" and "VIP" Represent the Adjusted and Variance Inflation Factor, Respectively

	Unstandardized Coefficients		Standardized Coefficients β	t	R^2 ($_{adj}R^2$)	F	VIF
	B	SE					
Model 1							
(constant)	18.815	2.463		7.638***	0.473 (0.471)	172.548***	
Total Number of pigmented spot	1.245	0.095	0.688	13.136***			1.000
Model 2							
(constant)	82.349	21.014		3.919***	0.498 (0.492)	94.618***	
Total Number of pigmented spot	1.007	0.121	0.556	8.296***			1.711
Spot intensity	-0.370	0.121	-0.204	-3.043**			1.711

**$p < 0.01$, ***$p < 0.001$

Table 2. Pearson's Correlation Results of Each Pigmented Spot Class with Age Number (No.), Size, and Intensity (I) of Each Pigmented Spot Class Correlated with Age. *p-value < 0.001

	Pigmented spot class			
	2 ~ 4 mm^2	4 ~ 10 mm^2	10 ~ 20 mm^2	> 20 mm^2
No.	0.514*	0.603*	0.420*	0.393*
Size (mm^2)	0.516*	0.599*	0.417*	0.377*
I (a.u)	-0.556*	-0.539*	-0.441*	-0.373*

Table 3. Pigmented Spot Number (No.), Total Size, and Intensity (I) Results of Each Age Group. Data are Expressed Mean ± SD. [†]: No Pigmented Spot Case Excluded from Data, Each Lowercase Letter and "n.s" Represent the Same Subgroup and Non-significant, Respectively

Index		Age group					
		20's	30's	40's	50's	60's	70's
Number of people		32	33	33	34	31	31
Mean ages		24.3 ± 2.71	34.1 ± 2.42	44.2 ± 3.25	54.4 ± 2.98	65.1 ± 3.18	73.3 ± 2.17
2 ~ 4 mm^2	No.	6.8[a] ± 3.03	10.7[bc] ± 4.65	10.5[b] ± 3.64	14.0[cd] ± 4.81	14.2[cd] ± 3.72	14.5[d] ± 4.71
	Total size	19.0[a] ± 8.72	30.1[ab] ± 13.23	29.9[bc] ± 10.27	39.4[bc] ± 13.65	40.0[c] ± 10.46	40.6[c] ± 13.11
	I	166.0[a] ± 5.82	163.9[ab] ± 6.69	157.8[bc] ± 7.66	155.6[c] ± 8.52	153.3[c] ± 8.52	151.8[c] ± 7.82
Class · 4 ~ 10 mm^2	No.	4.6[a] ± 2.80	6.2[ab] ± 3.46	8.1[bc] ± 2.80	10.1[cd] ± 4.32	10.9[cd] ± 3.30	11.9[d] ± 3.33
	Total size	28.5[a] ± 18.81	36.8[ab] ± 21.67	49.5[bc] ± 18.81	61.1[cd] ± 26.75	66.6[cd] ± 20.45	74.0[d] ± 21.64
	I	163.3[a] ± 7.10	162.0[ab] ± 7.89	155.8[bc] ± 7.53	152.7[cd] ± 9.6	151.8[cd] ± 8.14	148.8[d] ± 7.49
10 ~ 20 mm^2	No.	1.6[a] ± 1.54	2.0[a] ± 2.01	2.3[ab] ± 1.74	2.8[abc] ± 2.03	4.1[c] ± 1.75	3.9[bc] ± 2.26
	Total size	22.0[a] ± 6.75	26.6[a] ± 6.62	31.1[ab] ± 4.81	36.8[abc] ± 4.46	55.9[c] ± 1.99	51.5[bc] ± 3.56
	I	159.3[a] ± 8.07	157.0[ab] ± 6.33	152.0[abc] ± 9.24	149.3[bc] ± 10.30	148.3[c] ± 9.20	145.8[c†] ± 9.41
> 20 mm^2	No.	0.3[a] ± 0.94	0.7[ab] ± 0.88	0.8[ab] ± 1.15	1.2[abc] ± 1.53	1.5[bc] ± 1.39	2.2[c] ± 1.68
	Total size	10.6[a] ± 28.87	21.6[a] ± 27.72	26.8[a] ± 46.64	33.1[abc] ± 49.64	48.3[ab] ± 47.79	73.2[bc] ± 62.18
	I n[s]	153.9[†] ± 8.12	153.0[†] ± 8.91	147.6[†] ± 11.16	143.7[†] ± 12.78	143.2[†] ± 10.78	141.3[†] ± 11.2

Table 4. Comparison of Percentage of Pigmented Spot Analysis of Various Age Groups. Data are Expressed Mean ± SE (standard error), and Analyzed by One - way ANOVA

Age groups	Percentage (%)							
	No.				Total size			
	$2 \sim 4$ mm^2	$4 \sim 10$ mm^2	$10 \sim 20$ mm^2	> 20 mm^2	$2 \sim 4$ mm^2	$4 \sim 10$ mm^2	$10 \sim 20$ mm^2	> 20 mm^2
20's	52.7^{ab} ± 3.39	34.0 ± 3.05	11.0 ± 1.77	2.2^a ± 0.86	31.3^a ± 3.88	38.3 ± 3.75	22.8 ± 3.49	7.7^a ± 2.89
30's	54.8^a ± 2.43	31.9 ± 2.07	9.4 ± 1.58	3.9^a ± 0.90	29.6^a ± 2.51	34.4 ± 2.88	19.8 ± 2.98	16.1^{ab} ± 3.36
40's	48.4^{ab} ± 2.00	37.8 ± 1.79	10.1 ± 1.13	3.7^{ab} ± 0.90	25.2^{ab} ± 2.01	39.5 ± 2.50	21.7 ± 2.35	13.6^{ab} ± 3.06
50's	50.7^{ab} ± 2.08	35.9 ± 1.82	9.6 ± 1.11	3.8^{ab} ± 0.85	26.9^{ab} ± 2.05	38.5 ± 2.40	20.9 ± 2.37	13.7^{ab} ± 2.89
60's	46.1^{ab} ± 1.52	35.5 ± 1.43	13.3 ± 0.95	5.1^{ab} ± 0.88	20.2^{ab} ± 1.32	32.9 ± 1.78	26.8 ± 1.66	20.1^{ab} ± 2.98
70's	44.0^b ± 1.64	37.1 ± 1.55	12.0 ± 1.18	7.0^b ± 1.16	18.2^b ± 1.24	33.5 ± 2.44	20.9 ± 1.92	27.4^b ± 3.11
p-value	< 0.01	Non-significant	Non-significant	< 0.05	< 0.001	Non-significant	Non-significant	< 0.001

regression analysis which using the total number of pigmented spots, the total pigmented spots size, and spots intensity, the total number of pigmented spots and spot intensity significantly explained 49.2% ($_{adj}R^2$) of age ($p < 0.001$, Table 1). The standardized coefficient of the total number of pigmented spots and spot intensity were 0.556 and -0.204, respectively (Table 1). In addition, the results of correlation analysis between age and values of each pigmented spots class showed significant correlation ($p < 0.001$, Table 2), and the mean and SD of each age groups were expressed in Table 3. According to the ANOVA results, there were significant differences in pigmented spot number, size, and intensity among age groups (Table 3). Except for the class larger than 20 mm^2, in all other classes, the number and size of pigment spots increased and the intensity decreased with increasing age. There was a significant difference in the percentage of pigmented spots number between those in their 30's and those in their 70's, and between those in their 20's and those in their 70's, in the $2 \sim 4$ mm^2 and > 20 mm^2 classes, respectively (Table 4). In addition, there was a significant difference in the percentage of pigmented spot size between those in their 20's and 30's and those in their 70's, and between those in their 20's and those in their 70's in the $2 \sim 4$ mm^2 and > 20 mm^2 classes (Table 4).

4. Discussion

In this study, we analyzed the face of a Korean female based on the color of the digital image, and calculated the number, size, and intensity of pigmentation spots in the cheek areas. In addition, by categorizing each individual based on the size of pigmentation, the number and size of pigmentation per category of each individual were calculated. Although the types of pigmentation such as solar lentigines, melisma, nevus of Ota, PIH, etc. could not be distinguished, such as in previous studies[3,4], it was also quantitatively confirmed that the degree of pigmentation worsened with age. The melanin index was not directly confirmed in this study, but the darkening of the pigmented spots might be a result of increasing the amount of melanin. Also, through the stepwise multiple regression analysis, it was found that the total number of pigmented spots and spot intensity significantly explained age, and in particular, the standardized coefficient of the total number of pigmented spots was greater than that of the spot intensity, indicating that it has a greater effect than the spot intensity. When the total size was added as a factor in the multiple regression analysis, the standardized coefficient for total number of pigmented spots, spot intensity, and total size were 0.455, -0.144, and 0.174 respectively, and the significance probabilities were <0.001, 0.055, and 0.072, respectively. Ignoring the significance and focusing only on the effect on age, the order is number, total size, and intensity. In other words, the occurrence of pigmented spots itself has a greater effect than the intensity of already formed pigmented spots. In addition, we newly discovered that there was a difference in the proportion of the pigmented size with

increasing age. The proportion of small size of pigmentation decreased and the proportion of large size of pigmentation increased. Although pigmentation of a large size such as melasma can occur, it is surmised that small pigmentation gradually increases or the pigmented spot merges with neighboring pigmented spots to become a large pigmentation. The process of small objects merging to form a larger object is an aging phenomenon that occurs in pores or wrinkles [9-11], and pigmentation is also an aging phenomenon, so it is assumed that the same process will occur in skin pigmentation. However, since this study is not a longitudinal study, further research using a longitudinal method with the same subjects is needed. In summary, pigmentation does not improve naturally, so it is necessary to care of the skin color continuously from the 20's with small pigmentation.

5. Conclusions

Facial skin will have more pigmented spots with age, and the increase in the large pigmented spots is the most noticeable phenomenon in Korean female. In addition, since skin pigmentation is one of the aging processes, it is necessary to take steady care of pigmentation from the early 20's.

Acknowledgement

Conflict of Interest

All authors are employees of AMOREPACIFIC Corporation.

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