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From the Standpoint of Dermatology

Toshihiko NUMAHARA[*1] (numahara@kms.ac.jp)
[*1]Department of Dermatology, Kagawa Medical University

Abstract:

Because skin color directly reflects every pathological change of skin that causes modification of its optical characteristics, it is vital information in dermatological diagnosis. Photographs have played a substantial role for a long time in recording skin lesions, and recently digital imaging has been introduced for this purpose. But the quality of skin color images reproduced by any currently available imaging system does not meet the requirement for dermatological diagnosis; therefore, they are not yet considered a substitute for the observation of the real objects and only subsidiary roles are given to them.

However, if advanced digital imaging technologies including multispectral imaging are in a position to reproduce images which can be equally used as real objects, revolutionary changes are expected in dermatological practice as well as in dermatological education. If, on the other hand, the technology of digital imaging fails to achieve a higher quality as mentioned above, a huge investment in electronic patient records and tele-medicine would run the risk of having been made in vain in the field of dermatology.

1. Understanding human skin and its color

1.1 The structure of human skin (Fig. 1)

The thickness of human skin except for subcutaneous tissue varies from 1.5 mm to 4.0 mm according to age, sex or body regions. The most superficial layer of the epidermis is the keratin layer, which is 0.02 mm thick generally and 0.5 mm thick at the palms and soles of the feet. The epidermis has melanocytes in a 10 percent ratio of all cells in its basal layer and they supply melanin to keratinocytes. This melanin plays a great role in protecting the skin from the harmful effects of ultraviolet light. In the dermis, the papillary layer just under the epidermis is rich both in capillaries and in the terminal organs of sensory nerves, and the reticular layer that accounts for the most part of the dermis is rich in collagenic fibers.

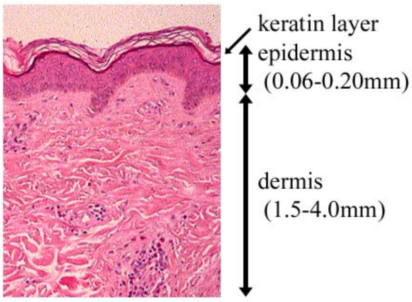


Figure 1 A typical cross section of human skin

Chief coloring factors that relate to skin color are the melanin pigment in the epidermis and the blood hemoglobin in the superficial layer of the dermis.

1.2 The origins of skin colors [1-3]

In short, illuminated light which comes into the skin is scattered in the dermis and a part of it is absorbed by melanin and hemoglobin, then the rest of the light makes the familiar flesh color (Fig. 2). Increased melanin in the epidermis intensifies the brownish tone of the skin color, and dilated vessels in the inflamed skin cause a more reddish tone of skin color (Fig. 3). Also, other pigments such as bilirubin and carotene in plasma as well as changes in the optical characteristics of the keratin layer or of the dermis have considerable influence on skin color. For example, if the keratin layer is thicker or drier, more light is scattered and consequently the skin increases its opacity (Fig. 4).

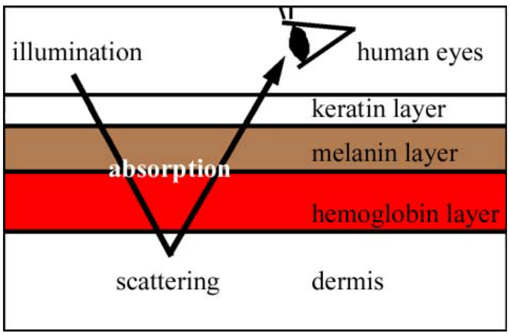
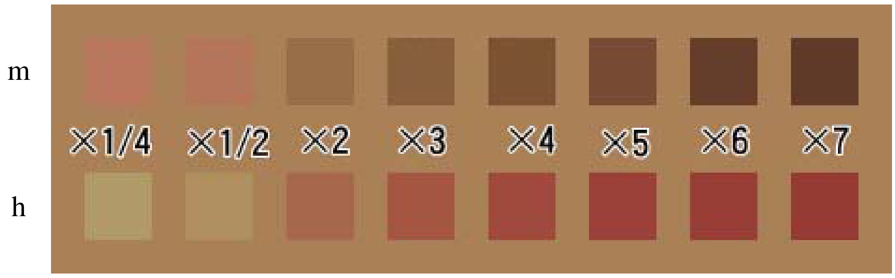


Figure 2 A simple model of optical characteristics of human skin

Illuminated light which comes into the skin is scattered in the dermis, and a part of it is absorbed while passing through the layer of melanin and hemoglobin, then the rest reaches the observer's eyes. (modification of Takiwaki's work [1])



m : melanin h : hemoglobin

Figure 3 Simulated skin colors (A)

Simulated skin colors corresponding to various amounts of melanin (upper row) and hemoglobin (lower row) contained in the skin, which are indicated by their ratios to the normal amount of each element, are shown. The background color represents the normal standard. (produced by Takiwaki's simulator [2])

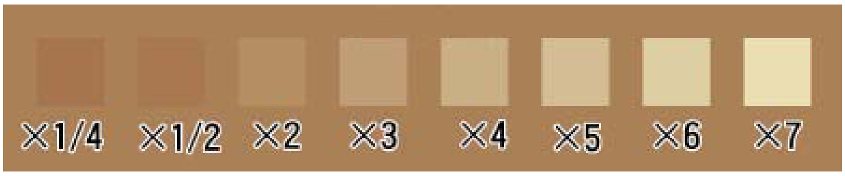


Figure 4 Simulated skin colors (B)

Simulated skin colors corresponding to various scattering of light at the keratin layer, which are indicated by their ratios to the normal one, are shown. The background color represents the normal standard. (produced by Takiwaki's simulator [2])

The dermis is often compared to agar containing milk because it requires a certain thickness to appear to be white. Its pathological changes such as atrophy, degeneration and edema cause modification of its optical characteristics and consequently make up the changes in skin color.

In the dermis, light of a longer wavelength (red light) penetrates more easily than a shorter one, and contrarily, light of shorter wavelength (blue light) is scattered more than a longer one. When there is a substantial amount of pigment in the deep layer of the dermis, a larger amount of light of a shorter wavelength, which tends to be scattered in the superficial layer, reaches observers' eyes than light of longer wavelength, which tends to penetrate the dermis and be absorbed by the pigment in it. This is the reason why dilated capillaries and strawberry marks in a superficial layer of skin look vivid and deep red and, on the other hand, veins and hemangiomas in a deeper layer look bluish. In the same way, junction nevi made of melanocytes situated at the boundary between the dermis and the epidermis look brownish, but blue nevi situated in the dermis look bluish as its name indicates, and nevi of Ota and Mongolian spots, both of which are made of dermal melanocytes, also look bluish (Fig. 5).

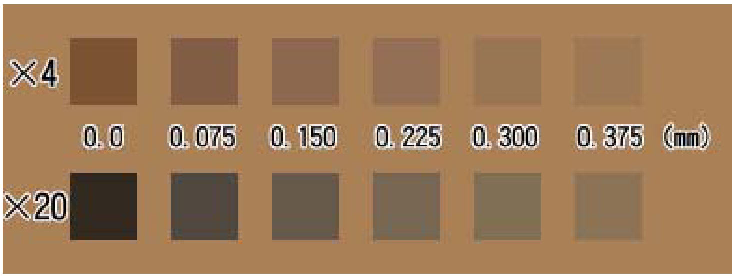


Figure 5 Simulated skin colors (C)

Simulated skin colors corresponding to various depths in the dermis indicated by millimeters, at which the melanin pigment is 4 times (upper row) or 20 times (lower row) as much as that in normal skin, are shown. The background color represents the normal standard. (produced by Takiwaki's simulator [2])

2. Skin color and dermatological diagnosis

In dermatology, because the macroscopic pathology of lesions is directly observed and used to evaluate their microscopic changes, visual findings are essential for diagnosis. Dermatological findings include major skin signs of the lesions: (1) type, (2) shape, (3) arrangement and (4) distribution, and especially skin color is vital information for interpreting the characteristics of lesions and the depth at which they exist in the skin (Fig. 6). Therefore various terms including white, red, pink, violaceous, brown, black, blue, gray, orange, yellow, etc. and more delicate ones, for example, salmon pink, slate, cafe au lait, black pearl, heliotrope and waxy are used to describe the colors of skin lesions.

Among the colors seen in various skin diseases, the diagnostic importance of red in immunologic and inflammatory disorders is larger than that in proliferate and neoplastic ones (Fig. 7). Deep red reflects severe inflammation, vivid red reflects an acute condition and purplish red reflects damage in the basic layer of the epidermis.

Figure 6 A case of melanoma in a forehead

Melanoma tissue in a superficial layer of skin has brownish colors and one in a deep layer has black or dark blue colors. The tumor seen to the lower right of the center of the photograph forms an elevated mass.

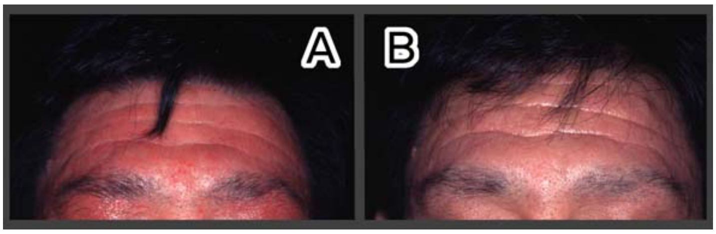


Figure 7 Eczema in a healing regimen

The red area of skin in inflammation seen in image A is remarkably reduced in B.

3. Visual records of skin lesions

In dermatology, visual recording of skin lesions is extremely important. Its long history has centuries of precise sketches, nearly a century of moulages, which are lifelike models of simulated shapes and colors of skin lesions, and thereafter decades of 35 mm photographs, which have long been considered to be the de facto standard. Nevertheless, these technologies are not considered to be able to substitute for observing the real objects because of limitations in their fidelity and durability. Therefore expenses for these processes are not reimbursed by medical insurance in Japan.

4. Digital imaging required for dermatological diagnosis

The recent progress and rapid spread of digital imaging technologies have brought digital cameras and desktop computers equipped with handy image processing software into medical practice. In dermatology, they are required to record accurate skin colors, especially fine red colors, and to reproduce them, but there is an extremely wide range of variation, not only among healthy and diseased skin, but also among the racial skin differences of Caucasian, Asian and black individuals. In reality, there are definite limitations and large differences in the colors reproduced by the various equipment used for digital imaging, which may incidentally cause erroneous diagnoses (Fig. 8). The author personally experienced serious problems of this kind in publishing a CD-ROM based color atlas for the instruction of dermatological diagnosis [4].

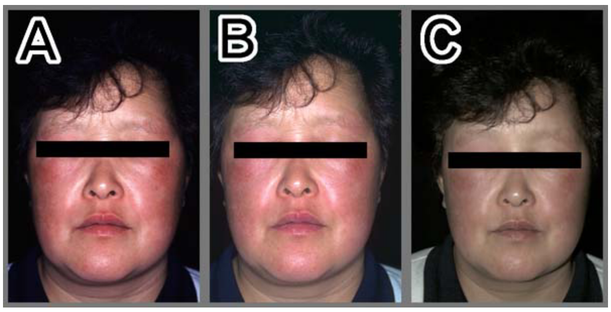


Figure 8 Pictures produced by three different systems

Picture A seems to be the closest to the actual color. The difference in color shown here may affect the diagnosis of illness or the interpretation of severity.

If digital imaging technology stays in the present state and does not achieve the quality required, then a huge investment made in electronic patient records and tele-medicine would run the risk of having been made in vain in the field of dermatology.

Contrarily, if advanced digital imaging technologies can reproduce images which can be equally used as real objects for dermatological diagnosis, revolutionary changes in medicine may be expected. Precise dermatological findings are conveyed when a patient is introduced to a distant physician or a medical consultation is made with a distant specialist. In addition, the importance of morphological records in dermatological practice as well as in dermatological education will be extremely increased.

5. Conclusions

Accurate color reproduction in digital imaging is one of the vital issues in dermatology of 21st century; therefore, research activities like this symposium focused on it are expected to evolve further and to play important roles in establishing new and effective standards based on highly advanced imaging technologies, including multispectral imaging, to solve the emerging color problems confronting us.

Acknowledgments

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