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Assessment of the colors of melanin pigment in acral compound nevus by using a novel dermoscopy technique with surgical light illumination and saturation analysis

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Introduction

On dermoscopy, the amount and location of melanin pigment can be assessed on the basis of its colors, ranging from black, brown to blue-gray. However, accurately recognizing a variety of melanin colors is sometimes difficult because the color of melanin pigment might change according to the character and intensity of lighting, and small melanin particles of different colors might be intermingled with each other. To resolve this issue, we developed a novel technique involving the use of surgical light illumination and saturation analysis.

Dermoscopy

Dermoscopic images were taken by using a self-made contact non-polarized dermoscope, consisting of a digital camera, macro lens, and transparent acrylic spacer. Dermoscopic examination was performed under surgical light illumination, with a gel applied to the skin surface (Figure 1).

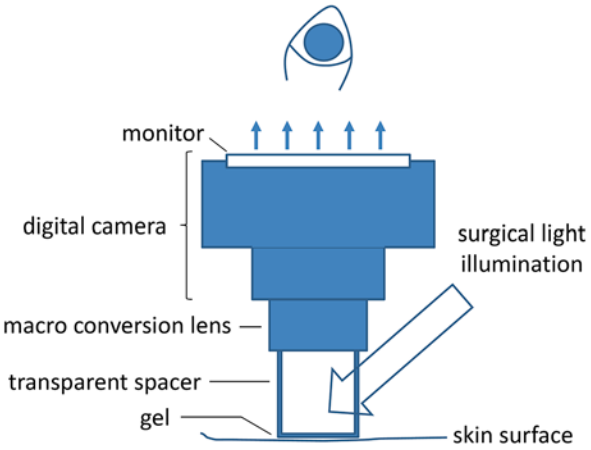

Figure 1. Dermoscopic images were taken by using a self-assembled contact non-polarized dermoscope consisting of a digital camera, macro lens, and transparent acrylic spacer. Dermoscopic examination was performed under surgical light illumination, with a gel applied to the skin surface. (Copyright: ©2014 Sakai et al.)

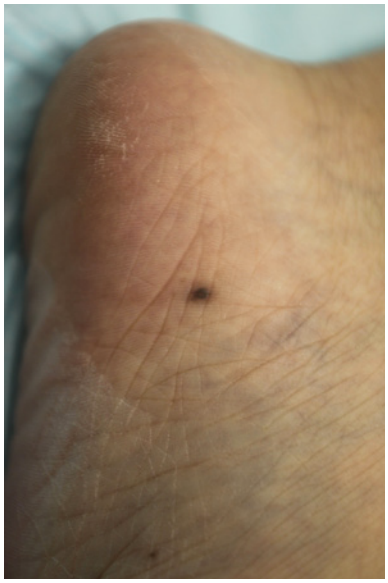

Figure 2. A black macule with a symmetrical border approximately 3 mm in diameter, suggesting the clinical diagnosis of melanocytic nevus.

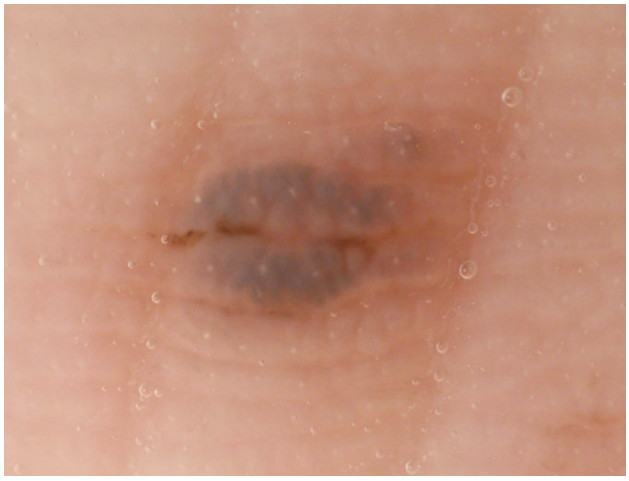

Figure 3. Monotonous blue-gray pigmentation on the ridges of the skin markings and brown linear pigmentation on the furrows. (Copyright: ©2014 Sakai et al.)

Case presentation

A 42-year-old Japanese woman presented with a pigmented skin lesion on the left sole. The lesion was first noticed three years earlier. Physical examination showed a black macule with a symmetrical border approximately 3 mm in diameter, suggesting the clinical diagnosis of melanocytic nevus (Figure 2).

Dermoscopic examination showed monotonous blue-gray pigmentation on the ridges of the skin markings and brown linear pigmentation on the furrows (Figure 3). The parallel furrow pattern suggested acral nevus; however, the parallel ridge patterns suggested the possibility of acral melanoma. A biopsy was taken from the lesion to help exclude acral melanoma, and tissue sectioning was performed perpendicular to the skin markings.

Histopathological examination of the biopsy specimen showed well-defined nests of melanocytes with no nuclear atypia or mitotic figures. The nests were located at the dermoepidermal junction or in the dermis. Nests in the dermis were located mainly under the crista profunda intermedia, and nests ascending into the epidermis were not seen (Figure 4A). Melanin columns in the stratum corneum were observed faintly but exclusively above the crista profunda limitans (Figure 4B). Clinical and histopathological features established the diagnosis of acquired compound nevus.

Image analysis

First, on the basis of the hue-saturation-lightness (HSL) color model, we decomposed the dermoscopic image into

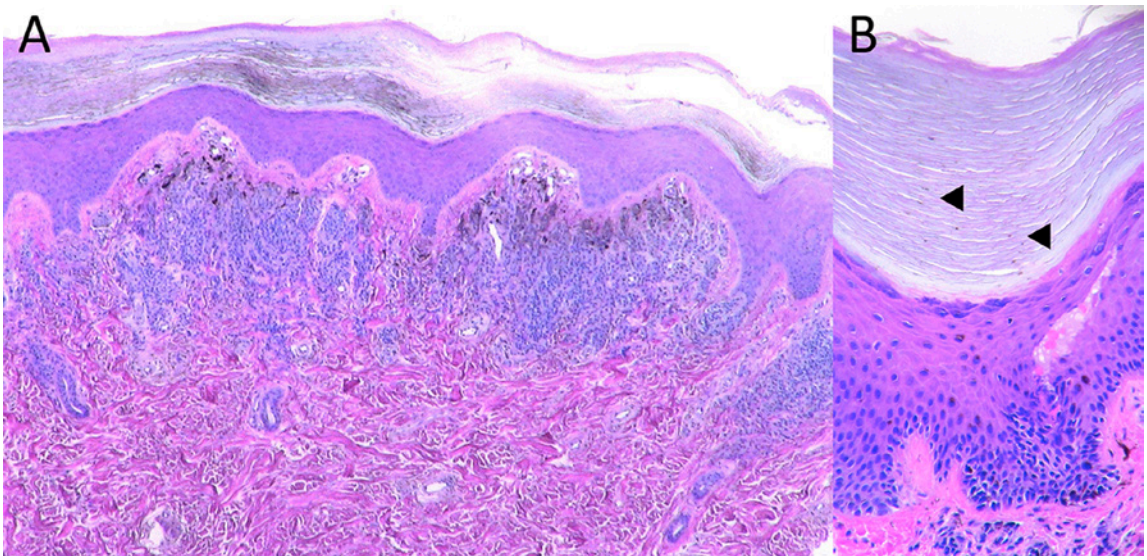

Figure 4. (A) Histopathological examination of the biopsy specimen showed well-defined nests of melanocytes with no nuclear atypia or mitotic figures. The nests were located at the dermoepidermal junction or in the dermis. Nests in the dermis were located mainly under the crista profunda intermedia, and nests ascending into the epidermis were not seen. (B) Melanin columns in the stratum corneum were observed faintly but exclusively above the crista profunda limitans (◀).(Copyright: ©2014 Sakai et al.)

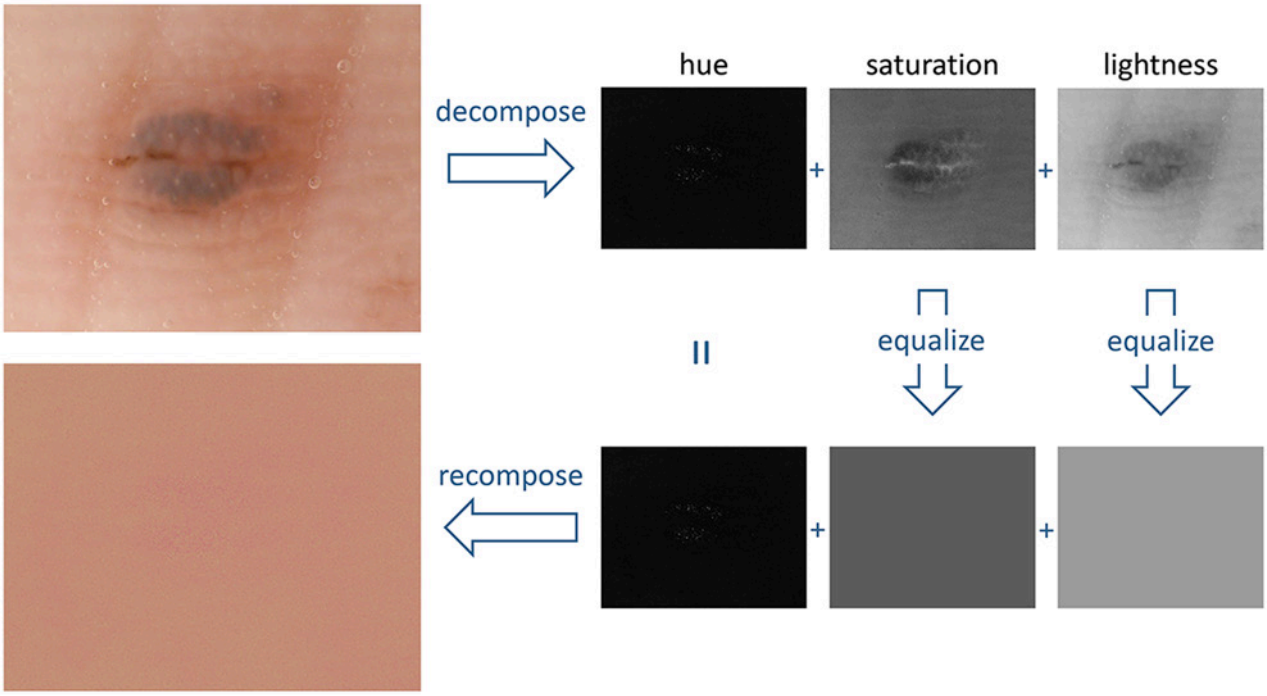

Figure 5. First, on the basis of the hue-saturation-lightness (HSL) color model, we decomposed the dermoscopic image into three grayscale images, the hue image, saturation image, and lightness image, by using GIMP2. Second, to estimate the hue level alone, we recomposed the image from the hue image, average saturation image and average lightness image by using GIMP2. (Copyright: ©2014 Sakai et al.)

three grayscale images, the hue image, saturation image and lightness image, by using GIMP2 [1] (Figure 5). In the grayscale saturation image, in which white represents maximum saturation (colorful) and black represents minimum saturation (grayish), unsaturated melanin pigments were observed on the ridges, and saturated melanin pigments were on the furrows (Figure 6). Note that the parallel furrow pattern due to saturated melanin was more sensitive and fine than the original pattern.

Second, to assess the hue level alone, we recomposed the image from the hue image, average saturation image and average lightness image by using GIMP2 (Figure 5). In the recomposed image, no notable changes in the hue level of the melanin pigment were detected either in the ridges or in the furrows compared to that of background skin (Figure 7).

Third, we constructed a three-dimensional image from the cut dermoscopic image, in which the altitude (z-axis) corresponds to saturation level, by using Image J [2] (Figure 8). In this image, low-altitude (unsaturated) melanin pigment on the

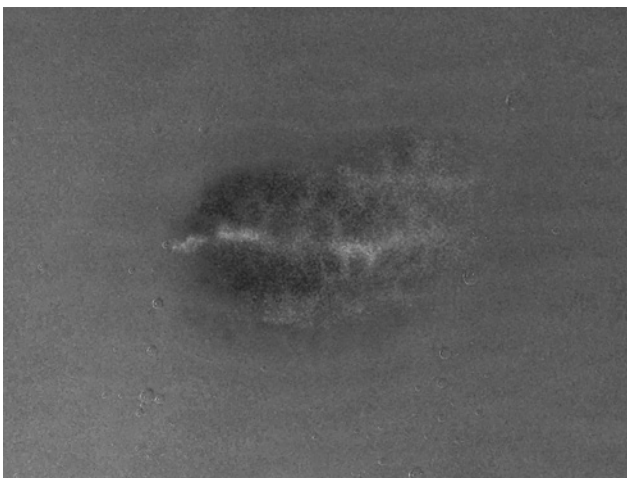

Figure 6. White represents maximum saturation (colorful), and black represents minimum saturation (grayish). Unsaturated melanin pigments were present on the ridges, and saturated melanin pigments were present on the furrows. (Copyright: ©2014 Sakai et al.)

Figure 7. No notable changes in the hue level of the melanin pigment were detected either in the ridges or in the furrows compared with that of background skin. (Copyright: ©2014 Sakai et al.)

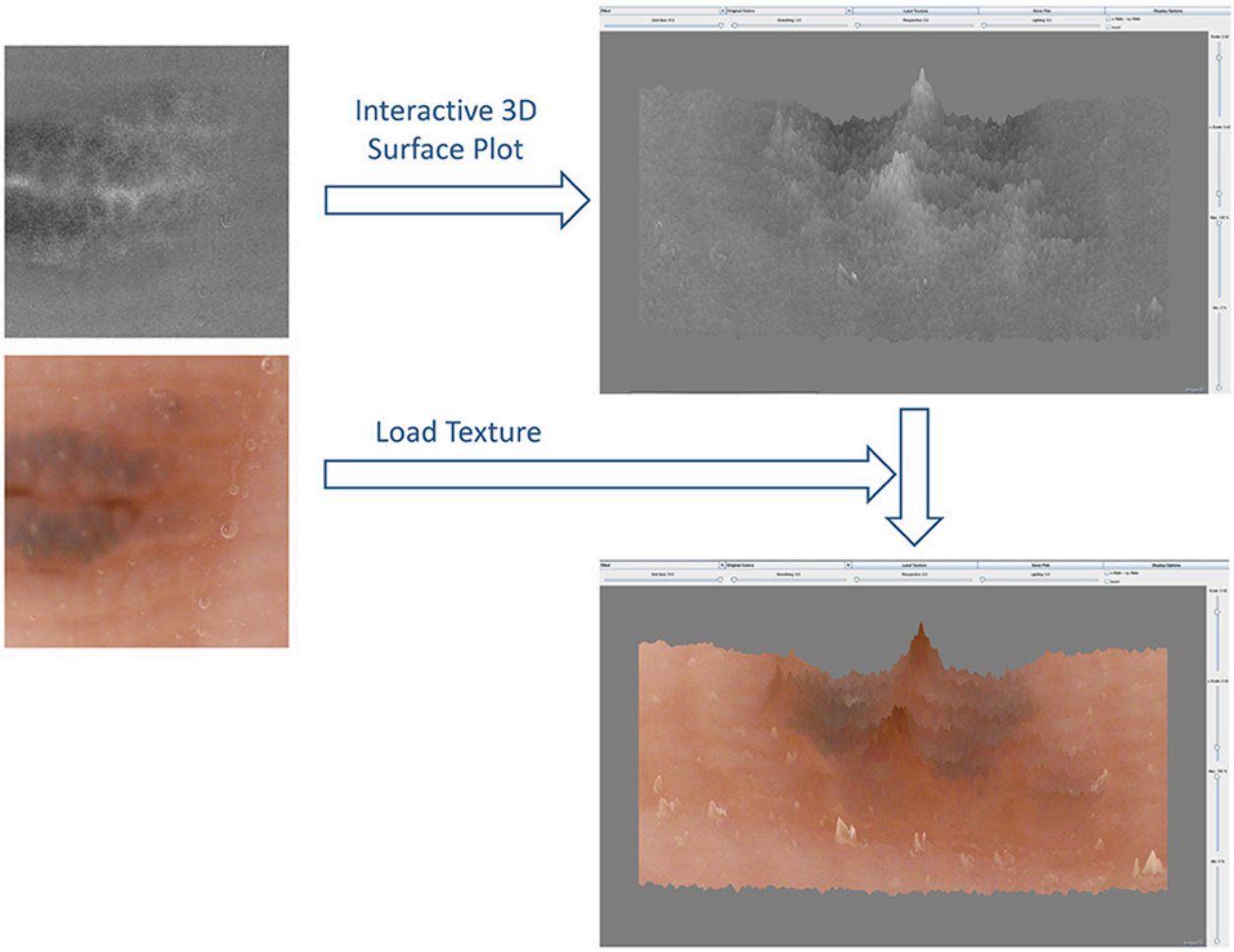

Figure 8. We constructed a three-dimensional image from the cut section of dermoscopic image, in which the altitude (z-axis) corresponds to saturation level, by using Image J. (Copyright: ©2014 Sakai et al.)

ridges appears blue-gray; high-altitude (saturated) melanin pigment on the furrows was brown (Figure 9).

Another case of acral compound nevus is shown in Figure 10.

Dermoscopic images of acral nevi (A–H) and their saturation images (A'–H') are shown in Figure 11. In these images, the parallel furrow patterns or fibrillar patterns in acral nevi are composed of saturated melanin pigments.

Figure 9. Low-altitude (unsaturated) melanin pigment on the ridges appears blue-gray; high-altitude (saturated) melanin pigments on the furrows were brown.

Discussion

In dermoscopy, it is established that the color of melanin pigment varies black in the stratum corneum, black to brown in the epidermis, brown to blue-gray at the dermoepidermal junction, to blue-gray in the dermis.

In acral compound nevi in the presented cases, dermoscopic-histopathologic correlation demonstrated that: (i) blue-gray pigment on the ridges may reflect the unsaturated melanin pigment in the melanocytic nests in the dermis or at the dermoepidermal junction, and (ii) brown pigment on the furrows may reflect the saturated melanin pigment in the stratum corneum or in the epidermis. In addition, in acral nevi in the presented cases, (iii) saturated melanin may vary in color from black to brown depending on the amount of melanin (Figure 12).

These findings indicate the following:

First, the depth of the melanin can be assessed according to saturation of the melanin pigment. Accordingly, the three-dimensional distribution of melanin pigment can be speculated according to the saturation level of each melanin particle.

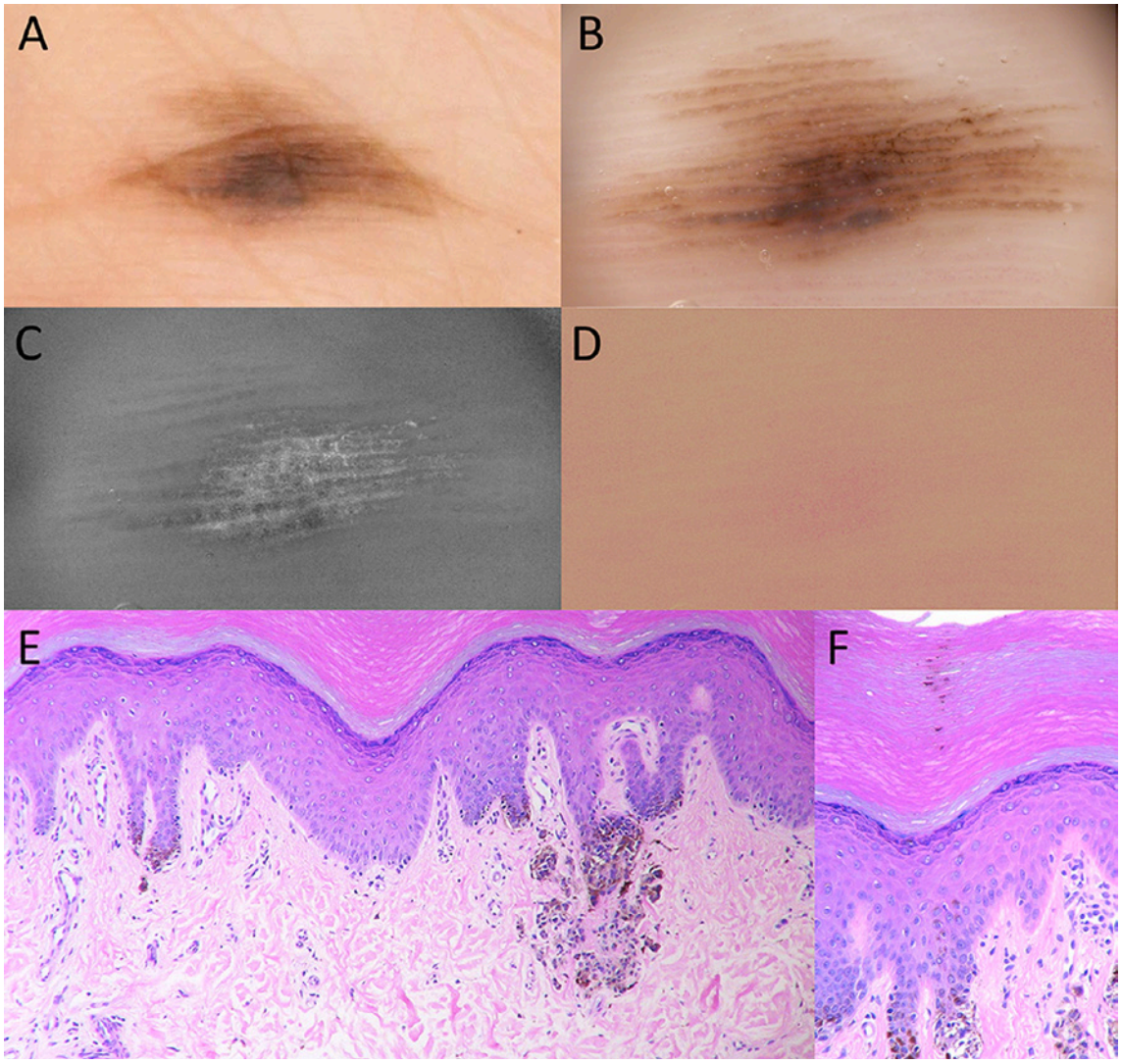

Figure 10. Another case of acral compound nevus. (A) A brown macule that was 12 × 5 mm in size. (B) Dermoscopy showed blue-gray melanin pigmentation on the ridges and brown pigmentation on the furrows. (C) The saturation image showed unsaturated melanin pigment on the ridges and saturated melanin pigment on the furrows. (D) In the recomposed image, no notable difference in hue level in the ridges and furrows. (E) Histopathologically, pigmented melanocytic nests were located in the dermis or at the dermoepidermal junction, and (F) melanin columns in the stratum corneum were observed above the crista profunda. (Copyright: ©2014 Sakai et al.)

Second, homogeneous blue ridges are equivalent to "blue areas," defined as small diffuse or speckled zones with a gray-blue or gray hue, which are related to the presence of melanophages and/or pigmented melanocytes within the superficial dermis [3]. Accordingly, the blue parallel ridge pattern (blue ridge sign) is defined as a benign variant of the parallel ridge pattern, due to melanin pigment in the melanocytic nests in the dermis or at the dermoepidermal junction, usually accompanied with the parallel furrow pattern typically seen in acral compound nevi.

Third, a large amount of saturated melanin may appear black, whereas a small amount of saturated melanin may appear brown or disappear blended into the background. On the basis of the report showing that dermoscopic patterns of acral nevi are thought to reflect melanin distribution in the stratum corneum [4], most of the saturated melanin may reflect the melanin granules in the stratum corneum. Accordingly, brown pigment on the furrows in acral nevi may reflect a small amount of melanin pigment in the cornified layer. On the basis on the report showing that the histological pattern of melanin distribution in the stratum corneum is key to discriminating early acral melanoma from acral nevus [5], the dermoscopic pattern of saturated melanin may provide clues to discriminating early acral melanoma from acral nevus.

On the other hand, change in colors to blue, related to the depth of melanin have been explained by the Tyndall effect in which short-wavelength visible light (blue) is dispersed and reflected more than long-wavelength light (red) [6]. However, in the presented cases, color changes to blue did not occur. The primary parameter related to the depth of melanin pigment is saturation.

In conclusion, depth assessment of melanin pigment by using saturation analysis is a new and important concept. Sat-

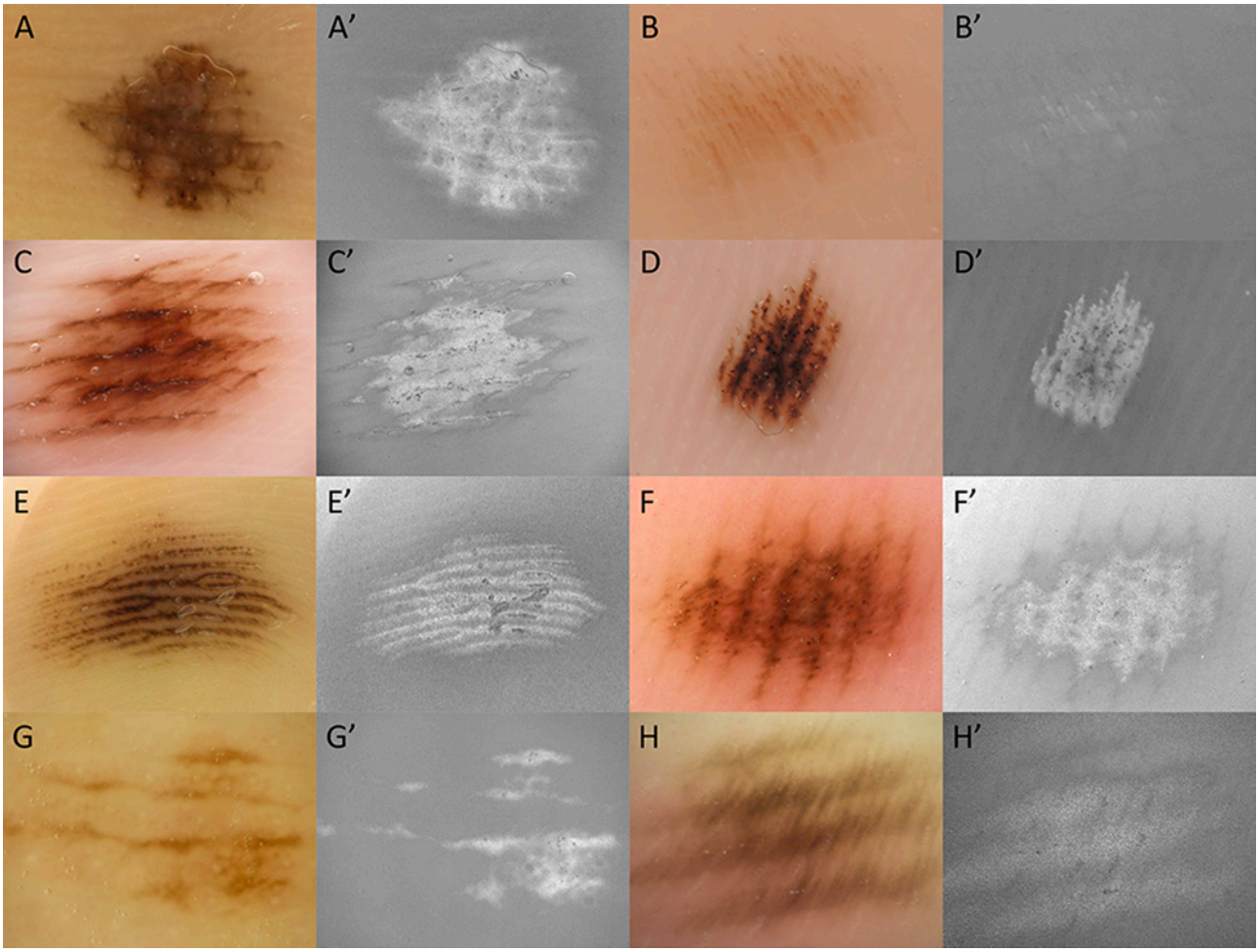

Figure 11. (A–H) Dermoscopic images of acral nevi. (A'–H') Saturation images of A–H. The parallel furrow patterns or fibrillar patterns in acral nevi are composed of saturated melanin pigments. (Copyright: ©2014 Sakai et al.)

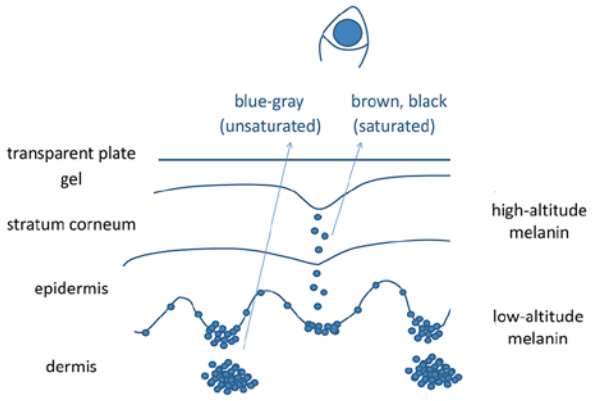

Figure 12. Blue-gray pigment on the ridges may reflect the unsaturated melanin pigment in the melanocytic nests in the dermis or at the dermoepidermal junction. Brown pigment on the furrows may reflect the saturated melanin pigment in the stratum corneum or in the epidermis. Saturated melanin may vary in color from black to brown depending on the amount of melanin. (Copyright: ©2014 Sakai et al.)

uration analysis can be applicable for evaluating the images of various pigmented skin lesions. Especially, the images from a non-contact polarized dermoscope might have superior saturation reproducibility of the deep skin structures. Saturation analysis and three-dimensional construction are easy-to-use and useful techniques for all dermatologists.

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