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The Dermoscopic Rainbow Pattern – A Review of the Literature

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ABSTRACT The "rainbow" pattern is a relatively new dermoscopic term that describes a bluish-reddish coloration together with various colors of the rainbow observable mainly through polarized light dermoscopy. Despite several theories, the rainbow pattern has not yet been clearly associated with any particular histological structure. This feature has been described in skin lesions with abundant vascularization such as Kaposi's sarcoma, basal cell carcinoma, scars, squamous cell carcinoma, melanoma, and others. In this paper we conducted a review of the available studies regarding the appearance of the rainbow pattern in different pathologies. Furthermore, we present a detailed description of the physical phenomenon in order to obtain a better understanding of this peculiar dermoscopic feature.

KEY WORDS: rainbow pattern, Kaposi's sarcoma, dermoscopy, polarized light, skin cancer, basal cell carcinoma

INTRODUCTION

Dermoscopy is a noninvasive skin imaging technique that allows clinicians to visualize the vascular architecture or the distribution of pigment that cannot be observed with the naked eye.

The metaphoric term "rainbow pattern" was coined by Hu *et al.* in 2009, when it was described as a bluish-reddish coloration together with various colors of the rainbow in six of seven patients with Kaposi's sarcoma (KS) (1). It was later suggested that these colors correspond to polychromatic lines and do not necessarily have a specific histological correlation (2). Since then, different authors reported that the rainbow pattern can also be observed in basal cell carcinoma, melanoma (3), stasis dermatitis, actinic keratoses, scars (4), lichen planus lesions (5), and several other entities (6-8).

THE PHYSICS OF THE RAINBOW PATTERN

The appearance of the rainbow pattern in dermoscopic examination is thought to be based on a series of physical phenomena such as diffraction, as the polarized light beam passes through the different skin layers until reaching the dermis (1). One theory, proposed by Vázquez-López *et al.* (8), associates this dermoscopic feature with the phenomenon of dichroism, in which the light in different states of polarization interacts with some areas of the tissue, resulting in various degrees of absorbance and retardance, therefore causing the appearance of different colors on dermoscopy. The absorbance of polarized light depends on the nature of the object and varies with the direction and location of structures in a layered, heterogeneously non-uniform object such as the dermis, producing a range of colors. The

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dermis contains a series of structures (e.g. collagen) that have different refractive indexes determining various amounts of absorbance and retardance. Additionally, dermal collagen is characterized by the property of birefringence (double refraction of polarized light), depending on the orientation of collagen fibers in relation to vectors of polarization. The light will thus be re-emitted from the skin in colored beams with randomized states of polarization (8).

THE HISTOLOGICAL BASIS OF THE RAINBOW PATTERN

The rainbow pattern could not, so far, be associated with any particular histological structure (5). The studies of Cheng *et al.* on KS lesions revealed that the pattern observable on dermoscopy is determined by the numerous vascular lumens lined by inconspicuous endothelial cells and scant stromal tissue, while skin lesions with abundant stromal tissue, such as hemangiomas, do not display similar dermoscopic aspects (1). This theory regarding the association between the rainbow pattern and the vascular structure of the lesion could also explain its appearance in other skin lesions with abundant vascularization such as scars, basal cell carcinoma, squamous cell carcinoma, and melanoma.

THE RAINBOW PATTERN IN KAPOSI'S SARCOMA

Kaposi's sarcoma is a multifocal vascular tumor affecting the skin and other organs. It is divided into four clinical groups: classic, epidemic, iatrogenic, and endemic. Histologically, KS is a vascular tumor characterized by the proliferation of endothelial cells and spindle cells (9).

In 2009, Cheng *et al.* (1) published a study on seven patients with histopathologically confirmed KS, none of whom had undergone topic or systemic treatment. The authors examined a total of 141 lesions between these patients and the majority was characterized by bluish-reddish coloration, which reflects the vascular structure of the tumor. The main histologic component of KS is represented by the numerous blood vessels, explaining its dermoscopic appearance with various color tones, from dark tones (red or blue) that correspond to a more vascular region of the tumor, to pale tones (whitish-blue, whitish-red, or white) describing a tumor area with less blood vessels and greater amounts of spindle cells and connective tissue. Some lesions showed small brown globules, representing hemosiderin-containing macrophages. These histological structures reflect the immaturity of this tumor's vascular structures.

The appearance of the rainbow pattern in KS is credited to diffraction, which causes the white light to be separated into different wavelengths when it passes through openings or slits with parallel alignment in close proximity to one another, the effect being more evident when the distance between the openings is similar to the wavelength of light. The vascular laminas of KS lesions are distributed in a "back-to-back" arrangement and separated by flattened endothelial cells. These vessels run parallel to the surface, forming vascular spaces that have a honeycomb-like pattern mimicking a diffraction device, thus explaining appearance of the rainbow pattern (Figure 1) (1).

Interestingly, the dermoscopic aspect of KS includes a bluish hue which does not appear in other vascular tumors except venous lakes, which also have

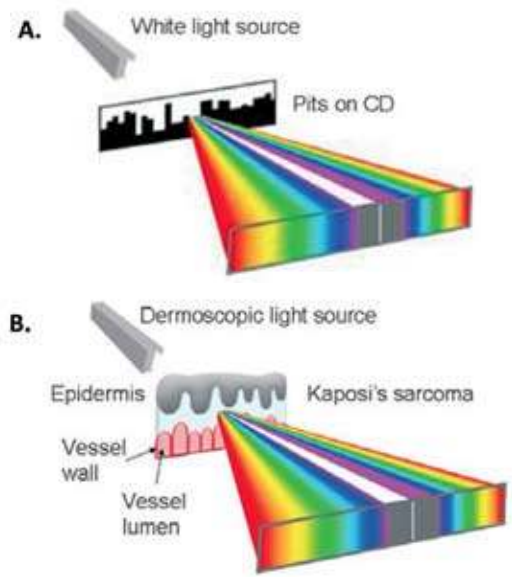

Figure 1. The physical basis of the "rainbow pattern". (A, B) White light is separated into different wavelengths as it passes through slits with parallel alignment in close proximity to one another.

a bluish aspect under dermoscopy. Moreover, the dermoscopic examination of Kaposi lesions does not reveal any lacunae structures, which can be observed in other vascular tumors such as hemangioma or angiokeratoma (1). Authors report the presence of the rainbow pattern in KS only under polarized light dermoscopy (PLD) (1). Our group has found similar dermoscopic features in KS lesions and one nodular BCC (unpublished results) (Figure 2).

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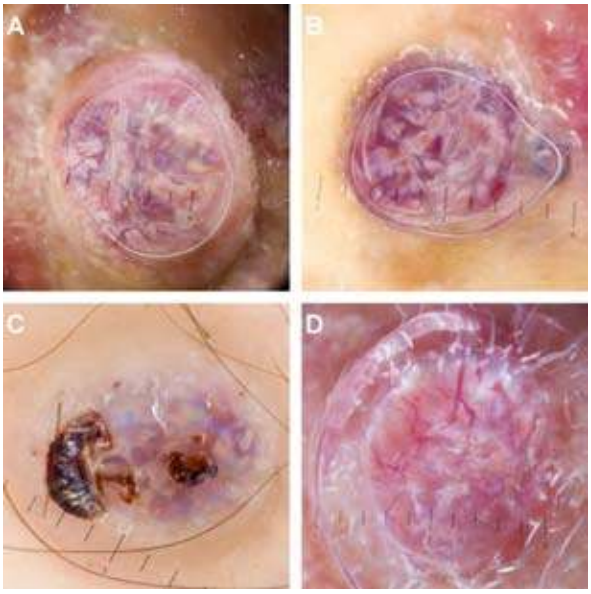

Figure 2. The rainbow pattern in skin tumors. (A, C) The rainbow pattern in several Kaposi's sarcoma lesions; (D) the rainbow pattern in a nodular basal cell carcinoma.

THE RAINBOW PATTERN IN BASAL CELL CARCINOMA

Basal cell carcinoma (BCC) represents the most common skin cancer in the Caucasian population, with an upward slope in incidence rates worldwide (10,11). It affects individuals of mid to late age and can cause extensive tissue destruction, infiltration of cartilage, muscle, or bone, and even intracranial extension (12); fortunately, it rarely metastasizes.

Current standards in basal cell carcinoma diagnosis include dermoscopy with well recognized features (13), *in vivo* or *ex vivo* reflectance confocal microscopy (14-16), and skin biopsy (12).

In BCC the rainbow pattern is attributed to the interaction between polarized light and vascular (1,9) and fibrous (17-19) structures that compose the histological architecture of these tumors. Suppa *et al.* examined 501 BCCs and found that the presence of the rainbow pattern on PLD is significantly associated with palpable lesions (plaque and nodular BCC) and that the pattern was curiously absent in lesions of the trunk (20).

THE RAINBOW PATTERN IN BLUE NEVI

Blue nevi are congenital and acquired melanocytic tumors that can be categorized into dendritic blue nevi, cellular blue nevi, and variants such as atypical cellular blue nevi and malignant blue nevi. Clinically, they present as solitary, multiple, firm blue, blue-gray or blue-brown nodules, plaques, or papules. The morphologic aspects of blue nevi include dermal proliferation of spindle, fusiform or ovoid cells, melanin inside melanocytic cells and macrophages, together with stromal fibrosis and collagen. All these structures can be observed on dermoscopy as structureless, homogeneous, bluish, steel-blue, or grayish pigmented areas. Vascular structures are not commonly associated with these tumors, but there are reports of cases in which a series of polymorphic, dotted, comma, linear irregular, and arborizing vessels were seen (21).

Starting from the theory of Vasquez-Lopez *et al.* (8) which attributes the rainbow pattern to dichroism, a group of authors from Turkey published a series of cases where they defined the rainbow pattern in blue nevi as an example of the interaction between light and skin structures, other than those of vascular lesions (2,22).

THE RAINBOW PATTERN IN OTHER CUTANEOUS TUMORS

The rainbow pattern has also been reported in cases of atypical fibroxanthoma, acral pseudolymphomatous angiokeratoma (6), Merkel cell carcinoma (7), haemosiderotic dermatofibroma (8), actinic keratoses, and scars (4).

Atypical fibroxanthoma is a rare, low-grade tumor, presenting as a rapidly evolving nodule on the sun-damaged skin of the head and neck in the elderly. Dermoscopic examination reveals irregular polymorphic vessels, white areas, and hyperpigmented structures. The rainbow pattern is observed in the center of the tumor, where the whitish areas can take the form of shiny white streaks or rosettes (23).

Pérez-Pérez *et al.* dermoscopically described scars as having numerous irregular vessels, telangiectasias, and a variable number of clusters of whitish points representing rosettes (4). The hypothesis that links the rainbow pattern to the angioarchitecture of the lesion may also explain why this pattern can be found in other types of skin lesions with active vascularization such as scars.

Acral pseudolymphomatous angiokeratoma is a rare benign skin disease that affects children between 2 and 13 years of age. It was initially considered a vascular malformation but nowadays is classified as a distinct type of pseudolymphoma. One paper (6,24) reports the presence of a cluster of reddish/violet or brown non-melanocytic features, with evidence of the rainbow pattern in the mid-peripheral area and whitish-pink areas in the center of the tumor. The atypical vascular pattern described in this pathology can also be found in other tumors such as squamous cell carcinoma, amelanotic melanoma, or Merkel cell carcinoma.

The rainbow pattern has also been reported in actinic keratoses, along with rosettes (1,4).

Merkel cell carcinoma (MCC) is a neuroendocrine tumor of the skin with a high rate of recurrence and metastasis presenting as a reddish-blue dermal papule or nodule that develops in a few weeks or months, has rapid growth, and is asymptomatic. Classically, linear irregular vessels and milky-red areas have been described on dermoscopy. Meo et al. reported the case of a MCC in the right frontotemporal area presenting rainbow patterned areas surrounded by a reddish background and dilated blood vessels throughout the entire lesion (25). The chaotic neoangiogenesis characterizing MCC could explain the presence of the rainbow pattern in this case.

Chiung-Tang *et al*. encountered the phenomenon in a case of large B-cell lymphoma on the leg, where the clinical and dermoscopic examination revealed a purple-black patch, erythematous papules, and central erosion with a bluish-reddish multicolored rainbow pattern (26).

CONCLUSION

The rainbow pattern is a relatively new concept introduced to describe a multi-colored dermoscopic feature which can be observed in various cutaneous pathologies. It was initially described in KS, but since the first description it has also been associated with other skin diseases such as BCC, melanoma, blue nevi, scars, or lichen planus. Even if the rainbow pattern was initially associated with vascular structures due to its presence in different vascular skin lesions, several papers noted that the correlation of the rainbow pattern with any particular histological structure is only speculative. Moreover, the rainbow pattern is accepted as being a more complex physical phenomenon in which polarized light interacts with different elements from the skin structures as it passes through tissues, not only vascular components of the skin layers. This aspect is supported by the description of this pattern in skin lesions in which the vascular component is not predominant, such as blue nevi or Merkel cell carcinoma. Due to the fact that the rainbow pattern is a relatively novel dermoscopic feature, further studies are required in order to establish its possible association with histological structures of the very different skin lesions in which it manifests.

Contributions

DC and LM have equally contributed to writing and editing the manuscript. LM acquired the dermoscopic images and prepared them for publication. VC, SI, VVM, and PMI contributed to literature research.

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